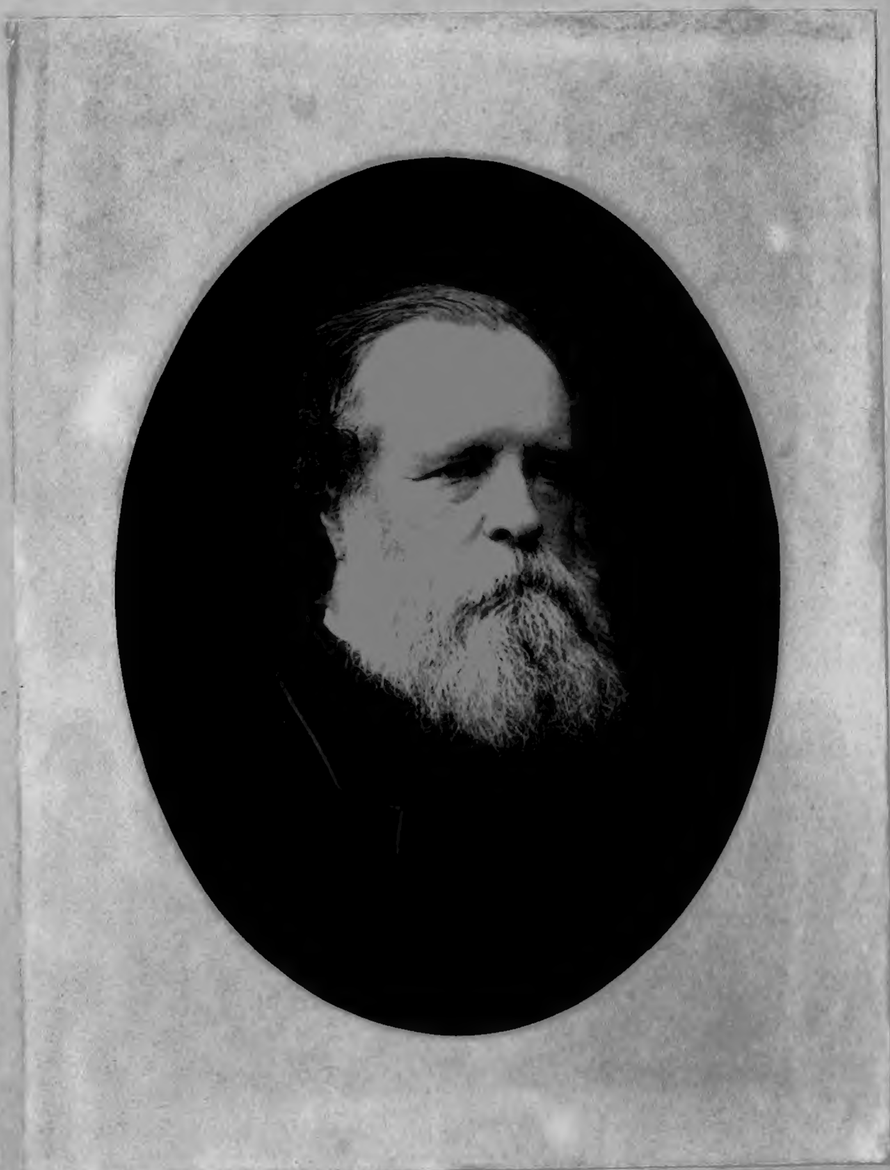


William Macleay

FREEMAN & CO., LIMITED SYDNEY.

Linnean Society of New South Wales.

THE

MACLEAY MEMORIAL VOLUME

EDITED BY

J. J. FLETCHER, M.A., B.Sc.

PUBLISHED BY THE SOCIETY

AND SOLD BY

ANGUS & ROBERTSON, AND TURNER & HENDERSON, SYDNEY,

DULAU & CO., 37 SOHO SQUARE, LONDON, AND FRIEDLÆNDER & SOHN, BERLIN.

September, 1893.

Price Three Guineas.

0851(1)

SYDNEY:

F. CUNNINGHAME AND CO., PRINTERS,

PITT STREET.

CONTENTS.

* The two plates illustrating these papers should have been numbered xxviii. and xxix. instead of xxix. and xxx. They were printed off, however, before it was known that a plate to which the number xxviii. had been assigned, was to be withdrawn.

CORRIGENDA.

Appendix to Paper No. IV. (On an apparently new Type of the *Platyhelminthes*, by Prof. HASWELL), p. 153.

"Since this paper passed through the press my attention has been directed by Prof. R. Blanchard, of Paris, to the fact that a genus *Actinodactylus* was established in 1890 by Duchassaing for a Tunicate. I, therefore, propose to alter the termination, making it *Actinodactylella.* I have omitted to give a specific name in the paper, and now propose to call this remarkable worm *Actinodactylella Blanchardi.*"—W. A. H.

Page 88, line 23—a full point has been omitted after Dieff.

Page 128, line 21—*for* decribed *read* described.

Page 220, line 24—for *Passiflora Hebertiana* read *Passiflora Herbertiana.*

For Plate XXIX. *read* Plate XXVIII.

For Plate XXX. *read* Plate XXIX.

PREFACE.

THE project for the publication of a MACLEAY MEMORIAL VOLUME to commemorate the late Sir WILLIAM MACLEAY'S eminent services to Science, brought forward by Professor HASWELL in his Presidential Address to the Linnean Society of New South Wales on January 27th, 1892, and adopted by the meeting, was actually entered upon shortly afterwards, and has at length, after many unforeseen but unavoidable delays, been accomplished.

The support which has been accorded to the undertaking by scientific men in all parts of Australasia has been highly gratifying—and the Committee of Publication regret that, owing to necessary limitations, they have been unable to find room for all the contributions which were forthcoming.

The following is a list of the private individuals and public institutions that have subscribed to the MACLEAY MEMORIAL:—

AGNEW, The Hon. J. W., M.D., M.L.C.
ALLAN, WILLIAM, Esq.
AUSTRALIAN MUSEUM, SYDNEY.
BAKER, R. T., Esq.
BALE, W. M., Esq., F.R.M.S.
BETCHE, ERNST, Esq.
BOYD, J. ARCHIBALD, Esq.
BRAZIER, JOHN, Esq., F.L.S., C.M.Z.S.
BROWN, HENRY J., Esq.
CAMPBELL, GERALD R., Esq.
CAMPBELL, The Hon. W. R., M.L.C.
CARSON, DUNCAN, Esq.
CHISHOLM, J. K., Esq.
CHISHOLM, J. W., Esq.
COBB, N. A., Esq., Ph.D.
COMBES, The Hon. E., C.M.G., M.L.C.
COX, JAMES C., Esq., M.D., F.L.S.
CRUICKSHANK, G. A., Esq.
DARLEY, CECIL W., Esq., M.I.C.E.
DAVID, Professor T. W. E., B.A., F.G.S.
DEANE, HENRY, Esq., M.A., M.I.C.E.
DE VIS, C. W., Esq., M.A.
DIXSON, CRAIG, Esq., M.D., M.R.C.S.
DIXSON, HUGH, Esq.
DIXSON, THOMAS, Esq., M.B., Ch.M.
DUNCAN, W. S., Esq.
ENGELHARDT, BRUNO G., Esq.
ETHERIDGE, ROBERT, Junr., Esq.
FIELD NATURALISTS' CLUB OF VICTORIA.
FIELD NATURALISTS' SOCIETY OF NEW SOUTH WALES.
FLETCHER, J. J., Esq., M.A., B.Sc.
FRENCH, C., Esq., F.L.S., F.R.H.S.
FROGGATT, WALTER W., Esq.
GARLAND, JAMES R., Esq., M.A.
HAMILTON, ALEXANDER G., Esq.
HASWELL, Professor W. A., M.A., D.Sc.
HEDLEY, CHARLES, Esq., F.L.S.
HILL, JAMES P., Esq., F.L.S.
HILL, J. R., Esq.
HOWES, Professor G. B., F.Z.S.
HURST, GEORGE, Esq., M.A., M.B.
HUTTON, Captain F. W., F.R.S., F.G.S.
JENNINGS, The Hon. Sir PATRICK, LL.D., K.C.M.G., M.L.C.
KERSHAW, W., Esq.
KING, The Hon. P. G., M.L.C.
KNOX, E. W., Esq.
LIVERSIDGE, Professor A., M.A., F.R.S.
LONG, The Hon. W. A., M.L.C.
LUCAS, T. P., Esq., M.R.C.S.E.
MACCABE, F. P., Esq.

MacCallum, Professor M. W., M.A.
Mackellar, The Hon. C. K., M.A., M.B., M.L.C.
Maclaurin, The Hon. H. N., M.A., M.D., LL.D., M.L.C.
Maiden, J. H., Esq., F.L.S., F.C.S.
Makinson, H. M., Esq.
Manning, The Hon. Sir William M., LL.D., K.C.M.G.
Martin, C. J., Esq., M.B., B.Sc.
Masters, George, Esq.
Merewether, E. C., Esq.
Meyrick, E., Esq., B.A., F.Z.S.
Milford, F., Esq., M.D., M.R.C.S.
Mitchell, David S., Esq.
Mitchell, John, Esq.
Morris, Augustus, Esq., C.M.G.
Musson, C. T., Esq., F.L.S.
Norton, The Hon. James, LL.D., M.L.C.
Oliver, A., Esq., M.A.
Olliff, A. Sidney, Esq., F.E.S.
Onslow, Mrs. E., Camden Park, N.S.W.
Onslow, J. Macarthur, Esq.
Palmer, Edward G. W., Esq.
Pedley, Perceval R., Esq.
Queensland Museum, Brisbane.
Rainbow, W. J., Esq.
Ramsay, E. P., Esq., LL.D., F.R.S.E.
Rennie, G. E., Esq., B.A., M.D.
Roberts, Sir Alfred, K.C.M.G., M.R.C.S.
Rose, J. H., Esq.
Rossiter, Richard C., Esq.
Royal Society of London.
Royal Society of New South Wales.
Royal Society of South Australia.
Royal Society of Victoria.
Science and Art Department, London.
Simson, Augustus, Esq.
Sloane, Thomas G., Esq.
Spencer, Professor W. Baldwin, M.A.
Steel, Thomas, Esq.
Stuart, Professor T. P. Anderson, M.D.
Sydney Observatory.
Tate, Professor Ralph, F.L.S., F.G.S.
Teece, Richard, Esq., F.I.A., F.F.A.
Turner, Fred., Esq., F.L.S., F.R.H.S.
Trebeck, P. N., Esq., J.P.
University of Sydney.
Walker, R. C., Esq.
Ward, R. D., Esq., M.R.C.S.E.
Williams, Percy E., Esq.
Wilson, Professor J. T., M.B., Ch.M.
Woolls, the late Rev. Dr., F.L.S.
Worcester, Thomas, Esq.

Messrs. Angus & Robertson, Sydney (three copies).
Messrs. Turner & Henderson, Sydney (six copies).

WILLIAM A. HASWELL,
JAMES NORTON,
R. ETHERIDGE, Junr.,
J. J. FLETCHER,
} Macleay Memorial Volume Committee.

September 25th, 1893.

The Hon.

Sir William Macleay, Kt.,

F.L.S., M.L.C.

Sir William Macleay, the last Australian representative in the male line of the old family name which for all but a century has had so honourable a place in the annals of biology and which so appropriately links together important biological beginnings in Britain and in her vigorous offshoot at the Antipodes, was one of a trio of notable men who, having made Australia their home, became completely identified with her welfare for the rest of their lives, so that their joint experiences embraced the greater part of the most important period of Australian history dating from the time when the country began to be something more than a penal settlement; men who combined in a remarkable degree scientific tastes with the characteristics and personal qualities of colonists of the most patriotic and enlightened type, and who amidst the drawbacks and distractions of life in a newly colonised country still found time and opportunity to cultivate their inherent love of natural history.

Alexander Macleay, the pioneer of the Australian Macleays, was born in the County of Ross on June 24th, 1767. His father, who was Provost of Wick and Deputy-Lieutenant of the County of Caithness, belonged to one of the oldest families in the north of Scotland. The son, Alexander, in 1795 became Chief Clerk in the Prisoners of War Office, in 1797 head of the Department of Correspondence of the Transport Board, and in 1806 Secretary of the Board, a post which he continued to fill until the abolition of the Board in 1818, when he retired upon a pension. In the year 1825, at the solicitation of the Earl of Bathurst, Mr. Macleay came out to Australia to undertake the important office of Colonial Secretary to the Government of New South Wales, which he held until the close of 1836. In 1843 he was elected first Speaker of the Legislative Council under the Constitution Act, a position which he filled with great ability, judgment and impartiality, so that on his resignation in May, 1846, by reason of his advanced age, he retired with the marked approbation of both sides of the House. Mr. Macleay died in Sydney on July 19th, 1848, in his eighty-first year.

Mr. Justice Therry in his "Reminiscences" thus refers to Mr. Macleay :—

"Amongst the leading families and persons who then [in 1829] dispensed a liberal hospitality, was the principal officer of Government, Mr. Alex. McLeay—a name favourably known to science as Secretary of the Linnean Society. . . . He shared in the Colony for a time a portion of the unpopularity attached

to some of the measures of Governor Darling. What share he may have had in their initiation and progress cannot now be easily determined. It may be that as Chief Secretary, he considered himself responsible for carrying out the mandates of his chief, and this may have induced him to identify himself more closely with the general character of his administration than an absolute obligation of duty imposed upon him. After he had ceased to hold office, public feeling took a favourable direction towards Mr. McLeay. He was returned a representative member at the first election, and chosen first Speaker of the Legislative Assembly, when a partially representative Legislative Council was conceded to the Colony. There, all measures of a liberal tendency found in him a warm supporter. A graceful tribute of recognition of his services was paid to him by his former chief opponent, Mr. Wentworth, when at the close of a long successful public career, no longer able from advanced years to perform the duties of Speaker, he relinquished office."* (p. 55).

In 1794 he was elected a Fellow of the Linnean Society of London, which was founded in 1788 though not incorporated until later, Mr. Macleay being one of the representatives of the Society to whom a Royal Charter was granted by His Majesty George III. in 1802; in 1798 he was appointed Honorary Secretary in succession to Mr. Marsham, and continued to act in that capacity until his departure for Australia. The following Minute of Council, subsequently adopted by a General Meeting of the Society, was thereupon entered upon the records of the Society :—

"The Linnean Society of London take the earliest opportunity after the retirement of Alexander Macleay, Esq., from the Secretaryship of the Society, to record upon their Minutes the high estimation in which he is held by them on account of twenty-seven years of unremitted and unrequited labour devoted to the interests of science; and that in quitting for a time this sphere of usefulness to fill an honourable station in a distant country, he carries with him the cordial esteem and sincere regret of this Society."

Mr. Macleay was elected a Fellow of the Royal Society in 1809; he was also a Foreign Member of the Academy of Sciences of Stockholm, and a Corresponding Member of the Academy of Turin.

As a naturalist he devoted himself almost exclusively to entomology, and at the time of his leaving England his collection of insects is said to have been the finest and most extensive at that time in the possession of any private individual. Though his knowledge of entomology was very considerable he never published anything on the subject; he is said, however, to have had in contemplation and to have made preparations for a monograph of the remarkable genus *Paussus*, which was well represented in his collection.

After his arrival in Australia his scientific tastes, even amid arduous official duties, soon found an outlet both in adding to his collections and in connection with the formation of a Museum, the nucleus of the present Australian Museum, the oldest of the Australian Museums. Dr. George Bennett, almost the last survivor of the early generation of colonists who were also naturalists, on his second visit to Sydney in August, 1832, thus refers to the subject :—

* Reminiscences of Thirty Years' Residence [1829-1859] in New South Wales, &c. 8vo. London, 1863.

"In company with a friend, I visited the Colonial Museum, which is arranged for the present in a small room, assigned for the purpose, in the Council-House, and which had been recently established in Sydney; it forms an excellent nucleus for a splendid collection, particularly in a country so prolific in rare, valuable, and beautiful specimens of natural productions. . . . The commencement of the public Museum is excellent; and Science, I believe, is indebted for it to the Honourable Alexander Macleay, Colonial Secretary; and may he see it attain an importance which no one can enjoy or appreciate more than himself, who has devoted the leisure moments of a long and arduous life engaged in other important occupations, to the study of the Natural Sciences. . . . To George Macleay, Esq.,* the Museum is indebted for many valuable species of birds, which he had collected during his arduous journey in the exploration of the course of the Murrumbidgee River, in the expedition under Captain Sturt. . . . The Council has liberally granted the sum of two hundred pounds annually out of the colonial funds for the support of the Museum."†

A few years later the collection had become of sufficient importance to allow of the issue of the first "Catalogue of the Specimens of Natural History, &c., in the Australian Museum," an 8vo. pamphlet of seventy-one pages published in 1837, long since out of print; and there must be very few colonial publications with a better claim than this Catalogue to be considered the first contribution, humble though it be, to the literature of natural history printed in Australia. It belongs to the primitive era when Sydney had a population of about 20,000 (19,729 at the time of the census of 1836), and to the very year in which Governor Bourke visited Port Phillip and approved of the site which Captain Lonsdale had selected, whereupon Mr. Hoddle, surveyor, "laid out the town of Melbourne and the Governor gave it its name." At this time the Australian Museum was managed by a committee consisting of Alexander Macleay, Esq., J. V. Thompson, Esq., Captain P. P. King, R.N., the Hon. E. Deas-Thomson, M.C., Charles Sturt, Esq., and George Macleay, Esq., with George Bennett, Esq., as Hon. Secretary. It was "open for the inspection of the public every Tuesday and Friday from 11 to 4"; and among the exhibits the most noticeable were specimens of thirty-six species of indigenous mammals and of three hundred and seventeen species of Australian birds, other orders being represented by smaller and less representative collections; in addition there were a few examples of foreign genera, as well as some ethnological and geological specimens.

William Sharp Macleay, second son of Alexander Macleay, was born in London July 21st, 1792, and was educated at Westminster, and at Trinity College, Cambridge, graduating with honours in 1814. Shortly after leaving Cambridge he was

* Third son of Alexander Macleay, afterwards Sir George Macleay, K.C.M.G. He came out to the colony shortly after his father, and accompanied Captain Sturt in his expedition of 1829-30. For several years he represented the Murrumbidgee electorate: but shortly afterwards severed his connection with the colonies. He died at Mentone, in June, 1891, in his 82nd year.

The last of this branch of the family, Mr. James Robert Macleay, died in London on October 28th, 1892, aged 81 years. He entered the Foreign Office many years ago, and spent some years at the Cape of Good Hope as Registrar to the Mixed Commission for the suppression of the slave trade. He also in his younger days visited Australia.

† Wanderings in New South Wales, &c., being the Journal of a Naturalist in these Countries during the years 1832-34. 2 vols. 8vo. London, 1834.

appointed Attaché to the British Embassy in France, and subsequently Secretary to the Board of British Claims on the French Government, established at the peace of 1815: in filling this office he spent several years in Paris, where he became acquainted with Cuvier and other distinguished scientific men. On his return to England he was promoted in 1825 to the responsible office of H.B.M. Commissioner of Arbitration to the mixed British and Spanish Court of Commission for the Abolition of the Slave Trade at the Havannah; in 1830 Commissary Judge in the same Court and later Judge in the mixed Tribunal of Justice. After ten years' residence in Cuba he returned to England in 1836 and in the year following he retired from the public service upon a pension. Until he finally left England he was an active member of the Zoological Society of London, then not long founded, and for some time he was a member of the Council. The change from a tropical climate to that of England proving detrimental to his health and comfort, Mr. W. S Macleay, influenced no doubt by favourable reports from Australia, decided to rejoin the members of the family there, and early in 1839 he arrived in New South Wales, where he spent the rest of his life. He died in Sydney on January 26th, 1865, in his seventy-third year.

As a member of the Board of Trustees of the Australian Museum Mr. W. S. Macleay warmly seconded the efforts of his father; and until ill-health compelled him reluctantly to retire, he is said to have been the life and soul of that Institution; by his advice and able co-operation also the Act for the establishment and endowment of the Museum was introduced, and subsequently passed into law. He was for several years a member of the National Board of Education, and for a short period a member of the Executive Council during Sir William Denison's administration, and before the inauguration of Responsible Government.

He was the author of "Horæ Entomologicæ, or Essays on the Annulose Animals" (1819-21), of the "Annulosa Javanica," 4to (1825), of the "Annulosa of South Africa," 4to (1838), "A Catalogue of Insects collected by Captain King, R.N." (1826), and of a number of important papers on various subjects which appeared in the Transactions of the Linnean and Zoological Societies, in the Zoological Journal, the Annals and Magazine of Natural History and other Journals. He did not confine his attention entirely to entomology; but though he added extensively to the collection inherited from his father, and accumulated both notes and sketches, he did not after settling in Australia write much even on Australian topics. Four short papers contributed to the Annals and Magazine of Natural History [Vols. VIII. and IX. 1841-42], and one to the Tasmanian Journal of Science [Vol. III. 1849], appear to be all that were published during his residence in New South Wales. In the latest but one of the former, an "Essay on the Natural Arrangement of Fishes," sent as a letter to J. McClelland, Esq., and published in the Calcutta Journal of Natural History, July, 1841, after-

wards republished in the Annals and Magazine, he says: "My residence on the sea-side enables me to increase my collection of marine genera [of fishes] . . . but my grand desire is to increase my collection of Annulose animals."

Mr. W. S. Macleay was among the early contributors to a knowledge of Australian insects, though his contributions were only two in number,* for his attention and interest were concentrated chiefly on the philosophical aspect of zoology, in investigating natural affinities and analogies, and in endeavouring to discover the natural system of classification, and consequently mere systematic work as such had no attraction whatever for him. That he was "satisfied that natural history had higher objects in view, than either to name the contents of a museum, to describe new species, institute new genera, or even to unravel the intricacy of synonyms" may be said of him as he himself says of a few French naturalists after "the majestic eloquence of Buffon and the profound observations of Bernard Jussieu were publicly known;"† at the same time he recognised "that the student in the more profound branches of the science ought to have already paved the way for this sort of research, by that intimate and extensive knowledge of species which can always be most easily acquired by artificial methods"; and he adds further: "We see, therefore, that naturalists must always owe a large portion of gratitude to those who may by the help of artificial systems have made the productions of nature generally known." (Hor. Ent. p. 51).

From the "Horæ Entomologicæ" in which were first broached the author's views to which at a later stage the epithets of the "Circular System" and "Quinarianism"‡ were applied, the following passage is worth quoting,

> "Had therefore my fears of criticism been given way to, I should certainly never have ventured on a work where I must be sure to merit it, and on the publication of new opinions which scarcely ever escape it; but I reflected that in the study of nature, the will to criticise produces investigation, and that investigation must always tend to the development of the truth; so that if I should be altogether in the wrong, the probability is that some good to natural history will have been occasioned in calling forth that investigation which is to convince the public that I am mistaken."

because his theories were hailed with acclamation by some of his scientific friends, more particularly the ornithologists Vigors and Swainson who pushed them to extremes so that they fell into disrepute, with perhaps some consequent obscuration

* An appendix to Part i. of the "Horæ" contains the descriptions of a number of peculiar Australian lamellicorns, for in defining genera he was strongly impressed with the value of a knowledge of exotic species (p. 89). The "Catalogue of Insects collected by Captain King, R.N.," appeared as an Appendix in that distinguished navigator's "Survey of the Intertropical and Western Coast of Australia" (1826).

† Hor. Ent. preface p. xxiii.

‡ A passage from the "Annulosa of S. Africa" will furnish a clue to the origin of these terms: "The conclusion to which we tend by such an analysis as the foregoing, is, that the lowest group in which species combine will be found, provided all the species are known, to return unto itself so as to form as it were a circle; and if we could suppose no species to be lost or to remain undiscovered, we should further find five of these lowest groups to form another circle, and five of these last circular groups to form another, and so on until we arrived at that grand circular group which is called the Animal Kingdom" (p. 52).

of W. S. Macleay's real merits; for he was admittedly a man of originality of mind and of very distinguished abilities. A recent critic by no means in sympathy with the views of Macleay's ornithological followers, refers to him as "a man of education and real genius."* The following passage from another source is also worthy of notice:—

> "It would be out of place here to enter into an analysis or criticism of this work (the 'Horæ Entomologicæ'), in which, however, it may be said are contained some of the most important speculations as to the affinities or relations of various groups of animals to each other ever offered to the world, and of which it is almost impossible to overrate the suggestive value. Speculative ideas, however, of such a general kind, even in the hands of their author, are apt to be carried too far in their application, and, when they fall into those of other speculators of less information and less capacity, can hardly fail to be grossly misused. This has been the case with Mr. Macleay's ideas; and thus, as observed by the author of a notice in the 'Reader,' of his labours, the name of the 'circular system' and of 'quinarianism' became almost by-words; and the work of one of the most thoughtful and original of English biologists sank at one time into most unmerited neglect."†

As in the case also of his father, it is a matter of regret that there is so little on record of first impressions of Australia, or of observations in natural history in the early days when the field was new; for it is precisely of such experienced and learned men, and in the case of so young a commonwealth, that the lament becomes so true that "one of the saddest things in life is to realise that in the death of the elder members of the community, so much that is precious in the way of knowledge and experience is lost to the world."

William John, or, as he called himself in later life, simply William Macleay, with whom we are more immediately concerned, unlike his uncle and cousin who at the time of their settling in Australia were men already advanced in years, with considerable experience of the world, and with European reputations, came out to the colony a youth of about nineteen with his career all before him. Yet imbued with the spirit of his predecessors, and by taking advantage of the opportunities which presented themselves, he shaped such a course for himself as, it is not too much to say, not only worthily to sustain but even to enhance the family reputation for zeal in the service of Science.

He was the second son of Kenneth Macleay of Keiss, and was born at Wick, County Caithness, on June 13th, 1820. He was educated at the Edinburgh Academy, and subsequently entered the University with a view of studying medicine, but before graduating the death of his widowed mother entirely changed his plans, and shortly after with his younger brother John he came out to Australia in the same ship as his cousin W. S. Macleay, arriving in Sydney in March, 1839.

* Ency. Brit. 9th Edit. Vol. XVIII. (1885), p. 15 (article "Ornithology").

† Obituary Notice of W. S. Macleay, Proc. Linn. Soc. London, 1864-65, p. cii.

Sir William Macleay's Australian career covering a period of nearly fifty-three years, throughout which, except for a few months' absence during the cruise of the Chevert, he never left Australia, presents three important stages. For the first fifteen years an active participation in the development of the material resources of the country kept him fully occupied; then as his success as a squatter became assured he turned his attention to politics during seven consecutive Parliaments; in the meantime his taste for natural history had begun to assert itself, and for fourteen years contemporaneously with his Parliamentary duties he did a good deal of scientific work; from the date of his retirement from the Legislative Assembly in 1874, and onwards for the rest of his life while health permitted, he gave himself up almost exclusively to the pursuit of biology.

Sir William Macleay did little directly to facilitate the work of any would-be biographer; consequently of the first period above referred to not very full details can now be given, though his pioneering experiences as recorded by himself could not fail to be interesting. Shortly after his arrival in the colony he and his brother John, like many others who came to Australia about the same time, decided on embarking their patrimony in squatting pursuits, which they accordingly did, first in the Fish River District, near Goulburn, afterwards in the Lachlan and Murrumbidgee Districts. Mr. John Macleay was of less robust constitution than his brother, and not long after his arrival, on account of his delicate health he set out on his return to England, but died on the voyage home. Sir William, though he continued to be largely interested in station property on the Murrumbidgee until within a few years before his death, was able from about the time of his entering Parliament to rely more and more on his managers, and to withdraw the active supervision of affairs which at first had been necessary; for a time indeed he was joined by another brother, Alexander Donald, who shared the responsibility of management, but who afterwards returned to Europe.

In the absence of fuller personal details, a little background of contemporary history may here be sketched in, because if it be true that "Men are what circumstances make them, and that it is especially the early circumstances and the minuter details in a young man's life that mould the character in the light of which the actions of the maturer years must be studied," then, looking at the commencement of his career in the light of the knowledge of its later developments and of its end, it is not unreasonable to suppose that the experiences and discipline of those early days had some not inconsiderable share in developing and accentuating the manly qualities which characterised him, and in after years bore such good fruit.

Not only had he the initial difficulties and hardships necessarily attendant upon a squatter's taking up new country to contend with, but these were intensified by a

series of events which occurred during the administration of the then Governor, Sir George Gipps (1838-46), which combined to make this period one of the most important epochs in the past history of Australia.

The need of enterprise and some of the pioneering difficulties to be encountered are suggested by the following extracts from a little book published by the late Hon. W. A. Brodribb, a squatter of some years' older standing than Sir William, and one of the speakers on the occasion of the opening of the Linnean Hall to be referred to later on :—

"At this time (1842), very little was known of the country situated on the western side of the main road passing from New South Wales to Victoria on the Lower Murray, Edward, Billabong, Murrumbidgee, Lachlan, and Darling Rivers. The general impression was that all this lower country to the westward was too dry, too flat, and too arid for any purpose, and the few who had travelled over it described it as a miserable, wretched, useless country. Some few localities were taken up on the banks of some of the rivers; little or no value was attached to them. Experience since has proved all this country to be the most valuable portion of New South Wales for the breeding and fattening of sheep, cattle, and horses, and the greater portion of the fat stock consumed in Victoria now is fattened in this country. Had the overlanders of 1842 been aware of this, they never would have gone to the expense and trouble of attempting to find the route to the new country named Gippsland, and discovered by the Count [Strzelecki]." (p. 24).

"I may here remark for many years all this country was considered useless for any purpose ; in fact, it was considered a desert for more than eight months in each year, and during the continuance of the hot weather, even if it would answer, the distance and bad roads to the markets would be another great objection to occupying it ; besides, the aborigines were hostile and dangerous.

"Notwithstanding, many of our young men, enterprising colonists, fond of novelty and danger, formed cattle and sheep stations on the banks of the permanent streams, such as Messrs. . . . William and John Macleay (nephews of the late Colonial Secretary, Mr. Alexander Macleay)," and others (p. 65).*

To some of the more important events which occurred during Governor Gipps' administration brief reference may also be made, for in giving full effect to the redtape measures of Downing Street, in whose interests very much more than in those of the colonists he administered the Government, Sir George succeeded in arraying against himself in bitter hostility and antagonism every colonial class and interest. Among other things his departure from the land policy of his popular predecessor, Sir Richard Bourke, rendered him particularly obnoxious to the squatters. Free grants of land offered in the interests of emigration having ceased in 1831, grants by purchase were introduced. In Governor Bourke's time the Crown lands of the interior suitable for pastoral occupation were offered for sale by auction at the upset price of five shillings per acre, the object being by not restricting but by encouraging occupancy of the land to an unlimited extent to promote the settlement of the country, and to stimulate colonisation of the right sort by giving freehold

* "Recollections of an Australian Squatter, or leaves from my Journal since 1835." By Hon. W. A. Brodribb, F.R.G.S., M.L.C. [8vo. Sydney : John Woods & Co. (1883).]

rights as an encouragement to permanent residence and interest in the country. Governor Gipps, on the contrary, among other innovations, proposed, at a time when the colony was already in financial difficulties, to make the purchase of a certain proportion of the land held compulsory at the end of each successive five years' lease, and to raise the upset price of Crown lands from five shillings per acre to the prohibitive one of twenty shillings, his idea being to restrict the sale of Crown lands until they could be sold at the price named, or as he says in one of his despatches to the Secretary of State, "I am an advocate for selling at a comparatively high price or not at all."

The troubles of the squatter arising from this source and having relation to the tenure of the land, however, were not all that at this time hampered his progress. Drought and bad seasons, intense commercial depression wide-spread and deep in the years 1842-4, during which stock of all kinds became almost unsaleable and advances of money were only procurable upon ruinous terms of interest and security, together with outbreaks of scab, catarrh, and anthrax among the flocks, supervened and well-nigh completed the measure of the squatter's woes.

A timely rise in the price of wool at the end of 1844, and the newly introduced practice of boiling down sheep for the tallow obtainable, mended matters somewhat; and finally the discovery of gold in 1851 with the much needed influx of population and consequent demand for stock of all kinds, helped the squatters out of their troubles and placed the colony shortly afterwards in the enjoyment of a full tide of prosperity.

The material welfare of the Australian colonies at the present time has a three-fold source—pastoral pursuits, agriculture, and mineral wealth, of which the first is not only the oldest, for as Dr. Lang says "Every Australian colony was necessarily in the first stage of its existence a pastoral colony," but still is the greatest source of wealth. It is not surprising therefore, that, as the squatters were the wealthiest and most powerful section of the community and included in their ranks men of good birth and education, they should have aspired to be represented in the Councils of the country. Such matters as land-tenure, the opening up of the country by roads and in due course the construction of railways, and others of cognate importance requiring legislative enactments underlay the great pastoral industry upon which the welfare of the country at first mainly depended and the expansion of which, reinforced by the discovery of gold, was so largely instrumental in laying "the foundation of an empire on the sweepings of British gaols."

Time has materially softened down, if it has not entirely extracted any sting from, the fierce denunciations with which Australian squatters as a class were assailed in some quarters only about forty years ago. No doubt there have been squatters

and squatters; but in the light of present knowledge of the careers of men like William Macleay and his contemporaries mentioned below—all of whom have but recently passed away—and of many others, some of them still with us, it would hardly do at the present time to apply to squatters as a class all that that trenchant divine, Dr. Lang, said of them in 1852, as follows:—

"Many of the squatters were men of standing and education from the mother-country, who had merely gone out to the colonies, as adventurers go to the East or West Indies, to make their fortunes and to return to England. Notwithstanding the vast tracts of pastoral country which they held in temporary occupation under their squatting licenses, very few of them were possessed of the fee simple of a single acre of ground in the colony. They had, therefore, no permanent tie in it—for very few of them were married—and no peculiar interest in its moral welfare and social advancement. Besides, a considerable number of these gentlemen were men of aristocratic notions and feelings, who disliked the advances that were evidently making by the middle and industrious classes of the free emigrant population around them, and who felt that their own dignity and self-importance would be much more easily maintained in the country if there were no middle class in the community at all—nothing, in short, between the master and the slave." (Vol. I. p. 386.)

And again: "Through the discovery of gold in Australia, and the consequent influx of population from the mother-country, the ascendancy of the squatters of the Australian colonies will also cease to determine. The object of these gentlemen was to occupy and engross the country for themselves exclusively, to partition it out in immense sheep-walks and cattle-runs, and (virtually) to prevent the influx and settlement of an agricultural population. Their object, in other words, was to keep the people down when they were down, and to give them no chance of rising for the future. . . . But this game is now *up*, and the days of squatting—in the sense of a powerful political party for whose aggrandisement the interests of the public were compromised and sacrificed—are now ended. Like the Grave, the Diggings have already levelled these past distinctions, and they are fast placing the wealth and property of the country in the hands of men of nerve and sinew—men of industry and perseverance—men of honesty and integrity; who are perfectly willing to accord to others all they claim for themselves—'a fair field and no favour.'"* (Vol. II. p. 425.)

One aspect of the other side of the question may be put in in a few sentences from a speech by the late Sir John Hay, the President of the Legislative Council, at a banquet tendered to Sir William Macleay by a number of his old Parliamentary friends on the eve of his departure in the Chevert in May, 1875. Said Sir John, who had been twitted by the late Hon. William Forster† with having been a squatter:—

"I must remind the honorable member who has spoken of me as a squatter who came to the front at an early period, that it has not been at all unusual for squatters to come to the front in political matters. I will bring to the recollection of my honorable friend that he himself was a practical squatter, and although the honorable gentleman's great squatting abilities have been lost sight of in a kind of halo of glory which surrounds his political character, still he is not less a squatter than I or my friend Mr. Macleay. My friend on the left, too [the Honorable John Robertson], who is now the Premier of the Colony, and the

* Historical and Statistical Account of New South Wales. By J. Dunmore Lang, D.D. Third Edition, 2 vols. 1852.

† Whose successful efforts in bringing under the notice of Mr. Krefft the type specimens of the Queensland mud-fish *(Ceratodus Forsteri)* are now a matter of history.

most notable public man amongst us, was a squatter, and came into notice whilst engaged amongst sheep and cattle, and with the stockwhip in the ranges. I am happy to say that having been a squatter in my early days, I can look back upon these facts with some degree of satisfaction. In fact, squatters have not only made politicians, but they have made very earnest and very unselfish politicians."

Among those who even before the introduction of Responsible Government desired to serve the country in the capacity of legislator, was William Macleay whose intellectual horizon was never at any time bounded by the possibilities of merely accumulating wealth. In 1855 he was elected to the old Legislative Council as Member for the Lachlan and Lower Darling, and in the year following, on the introduction of Responsible Government, he was returned to the first Legislative Assembly for the same constituency, which he continued to represent until 1859, after which until the dissolution of November, 1874, when he retired in order to devote himself more fully to the study of natural science, he sat as Member for the Murrumbidgee electorate in succession to his cousin George Macleay, already referred to, who retired and subsequently left Australia. In 1877 he was called to the Upper House, of which he remained a member for the rest of his life; and though he did not take a very prominent share in the deliberations of the Legislative Council, his keen interest in all public matters continued unabated.

As a politician Sir William was no office-seeker; he preferably took up the position of an independent member characterised by a sincere desire for useful legislation in the interests of the progress of the country. Firmly believing that the capital and the larger towns received more than a fair share of attention to the partial neglect of the inland districts, he consistently and warmly espoused the cause of the latter, especially in the matter of improving the means of internal communication. He was strongly impressed with the conviction that the extension of the trunk lines of railways would be an important factor in hastening on the development of the country, and in the case of the Southern line more particularly would tend to keep within the colony to which it territorially belonged a considerable amount of trade in wool and other produce which by the enterprise of a neighbouring colony and especially by the want of enterprise at home was in danger of being diverted.

As a sequel to his persistent advocacy of the extension of the Southern line of railway to the border, he had the satisfaction of being present, in September, 1878, at the opening of the line to Wagga, 309 miles from Sydney. And no one better than himself who had so often made the wearisome journey by road could better appreciate the importance of that extension. The journey from Sydney to Sir William's station, about 90 miles distant from Wagga, before the introduction of railways used to occupy him nine days, travelling in his own vehicle, and resting at night. The journey by mail coach, travelling day and night, was of course shorter, and for teams much longer. The journey by train to Wagga now occupies about ten

and a-half hours; while Kerarbury, Sir William's old station, from the Hay line can be reached in about twenty-one hours including stoppages.

Though his earnest advocacy of railway extension was the salient feature of his Parliamentary career of nearly twenty years, he at the same time took an intelligent part in the general work of the Legislature. As indicating some of the questions of the day in which he took a special interest it may be mentioned that he moved for the appointment, and was subsequently chairman, of the several Select Committees of the Legislative Assembly appointed to inquire into and report upon: "The defences of Port Jackson, and the best means of guarding the port and city of Sydney from foreign attack" (1863); "The distress at present existing among the working classes" (1866); "The alleged conspiracy for purposes of treason and assassination" (1868-9); and "The best mode of facilitating inland traffic and upon the subject of railway extension generally" (1870). We cannot better conclude the notice of this part of the subject than with a few extracts from the speech already referred to of Sir John Hay who by his long Parliamentary experience successively as Member, Minister, Speaker of the Legislative Assembly, and President of the Legislative Council, was eminently qualified to speak on the subject:—

"I have known Mr. Macleay for almost the whole period during which we have been in the Colony,* and as I think I am one of his oldest friends, I have peculiar pleasure in occupying the position [that of Chairman] to which I have been called to-night. I have had occasion at different times to express my regret that those who have owed so much to the Colony should have done so little in return; that those who were gifted with ability and wealth, and who owed everything to the land of their adoption or their birth, should not have thought it their duty to endeavour to assist in the councils of the country, to undergo those trials to which public men were subject in order that they might give those services they were capable of rendering. There is, however, one remarkable exception, and that is the example of our friend Mr. Macleay. I am not going to say that he might not have done more with his advantages and abilities; but we must at all events acknowledge that he had performed the functions of an independent member of Parliament in a manner which was in the highest degree creditable to him, and that he had retired from that position without a stain on his character. If Mr. Macleay had gone further and taken office during the term of nineteen years in which he sat as a private member of the Legislature, I think that he might have done more for the Colony than it was possible for him to do as a private member. But, however that might be, Mr. Macleay has set an example of fidelity and disinterestedness which is worthy of being imitated by those who aspire to become the representatives of a constituency in Parliament. Mr. Macleay has always been engaged in pastoral pursuits, but no one would venture to say that during his public career he had been influenced by considerations of self-interest; while his personal interests might have been identified with one particular class he had shown that, as a representative, he could rise superior to all such considerations; and his aim had been to promote the welfare of the people as a whole."

It was on the return journey from Wagga on the occasion of his re-election to Parliament in December, 1864, that Sir William came into collision near Plumb's

* Sir John Hay arrived in the Colony in 1838, about a year before Sir William; he died about a month later than his old friend (in January, 1892).

Inn on the Goulburn road on December 19th with one of the most notorious of the gangs of outlaws that during the gloomy period of 1863-66 infested the country and overawed large numbers of persons in the interior by their audacity and success. His courageous conduct on this occasion and his commendable example in successfully asserting, rifle in hand, his right to travel on the high road when three desperate ruffians, Gilbert, Hall, and Dunn, one of them a recent murderer of police, held possession of it on the hill overlooking the inn, and having just finished with the Goulburn coach were actively engaged in the process of "sticking-up" several teams and a number of travellers when Sir William, accompanied only by a boy who was driving the buggy, came on the scene and raised the siege, afterwards received official recognition by his being chosen one of seven gentlemen to whom in 1875 the Government awarded gold medals "granted for gallant and faithful services" rendered during the period when bushranging was rife.

During Sir William's early Parliamentary career the exigencies of Parliamentary life necessitated residence during at least part of the year in the metropolis, but about the time of his marriage, in June, 1857, to Miss Susan Emmeline Deas-Thomson, second daughter of the late Sir Edward Deas-Thomson, C.B., K.C.M.G.—a colonist of great merit and high standing who succeeded Mr. Alexander Macleay as Colonial Secretary—he made Sydney his permanent home. This paved the way for what after all was the most important work of his useful life, and for the service of greatest value rendered by him to his adopted country—the task he set himself of advancing the study of natural history in this colony, and this in a way not calculated to attract particular notice or provocative of the stimulus of public applause, and at a time when the prospects of the zoological branch of biology in Australia were not very brilliant, and its development in the embryonic stage.

And in taking this course not only did Sir William Macleay directly confer benefits of a substantial character upon Science, but the moral force of his example cannot be without beneficial influence in a community so young. He was essentially the product of his old-world birth and early experiences, of family tradition and example, and of the invigorating new-world influences under which he attained his maturity. Fortune rewarded his early efforts with success after experiences that were sharp if comparatively short, but found him indisposed for inglorious ease. In the rational utilisation of his knowledge and resources he found his work, and in carrying it through he may be said to have been inspired with the sentiment "of the larger, more generous, modern spirit of democratic society in which each man has the opportunity and is consequently under the responsibility to make the best of himself for the service of his fellow-men." And in some measure he found his opportunity in the fact, not a little strange, that the oldest of the three earliest of the Australian

colonies was the last* of which it can be said that, even to a partial extent, its "Government rightly understanding the relations which ought to prevail with the scientific societies judged to be deserving of their support" recognised the claims of such "to encouragement and assistance on the part of the State" on the ground of devotion "to scientific pursuits unremunerative to the members, but tending directly or indirectly to public benefit." And the example of a man of social position, without his sanity being open to question, devoting the best part of his life and of his wealth to the advancement of one branch of natural science—and that more particularly the most pressing for consideration, and yet which holds out least hope of pecuniary emolument, at any rate in the near future—not merely without any immediate prospect of the payment of dividends, but in the full expectation that never at any time can there be any direct return exactly calculable in terms of pounds, shillings, and pence, is one calculated to command attention and to do good outside the limited scientific circles of the country. And it is at once a tribute to the importance of the subject whose welfare it was his aim to foster, and a measure of his belief in the splendid heritage of work, over and above all that non-resident naturalists have done, are doing, or may do, which yet remains to Australian workers because of their residence in and personal knowledge of the country whose productions it is their aim to study. And not less also is it a protest against a disposition in some not uninfluential quarters in the colonies to believe that money spent on scientific objects is wasted unless, in the absence of directly remunerative results, there should be at least a substantial *quid pro quo* in the shape of an exhibition or show of some kind provided for the delectation or education it may be of the public, and the merits of which are so often thought to be enhanced by such considerations as the inclusion of at least one object of its kind "the largest in the world."

And in Australia over and above the interest which attaches to the subject in the abstract,† Biology has a special claim for recognition due partly to the intrinsic merits of the Australian fauna and flora, and partly to the deadly nature of the

* "In England, the Royal and other Societies are provided with splendid rooms in Burlington House, which must have cost the Government upwards of £100,000. . . . Coming nearer home, the Royal Society in Victoria received from the Government a piece of land in Melbourne, and £2000 towards the building, together with an annual grant of £200. In Tasmania the Royal Society is provided by the Government with fine rooms, and has an annual grant of money, and so in other places; while the Royal Society of Sydney has never received any assistance from Government except the printing of our Journal since 1873." [Mr. H. C. Russell's Presidential Address to the Royal Society of N.S.W., 1877, Journ. and Proc., Vol. XI. p. 6 (1878).]

† Biology "is now admitted to be one of the most important branches of general science, specially important in its relation to our material prosperity. Our food and raiment, the essentials of life, are derived exclusively from the animal and vegetable kingdoms; and biological products contribute largely to many of our luxuries; whilst, on the other hand, some of the greatest calamities with which we are afflicted are due to the rapid development of animal or vegetable life. Many are the associations, under Government as well as individual patronage, devoted to the improvement and increase of useful animals and plants; and of late attention has been also devoted to the arrest of the ravages of the noxious ones, the balance of natural selection being disturbed by the interference of agriculture and animal education. The due study of the means of restoring this balance, of turning it more and more in our favour, of calling in to our aid more and more of the hitherto neglected available species or of the hitherto latent properties of those already in use, of checking the progress of blights and murrains, requires a thorough knowledge of the animals and plants themselves; and that thorough knowledge can only be obtained by the scientific study not only of particular animals and plants supposed *à priori* to be useful or noxious, but of *all* animals and plants." [Presidential address to the Linnean Society of London, November 6th, 1873. By G. Bentham, F.R.S.]

struggle against numberless foreign and for the most part protected competitors in which, with the aid of all the appliances of modern times, the advent of civilised man with his belongings and his hangers-on has comparatively suddenly involved the terrestrial members thereof more particularly; so that over nearly the whole of a continental area equal in size to Europe, and in the short space of eighty years*—a period not transcending many a single life-time—the 'balance of nature' has been disturbed in so potent a manner as to threaten results in the not distant future analogous to those which in older countries have been the slower growth of centuries.

And as a considerable portion of the period mentioned is coincident with that during which the researches of Charles Darwin more particularly have added new interest to, and have so profoundly modified the aims and methods of the study of Biology; and as no second Australia yet remains to be discovered, it is not only eminently desirable that no time should be lost, and that no efforts should be spared to realise to the full the splendid opportunity of knowing in something like its entirety the fauna and flora of one great continental area so recently disturbed by civilised man, but the neglect to do so would be nothing less than culpable carelessness since such a grand opening can never again present itself. And the systematic observations and work necessary to complete the census of the flora and fauna would not only open up the field for the morphologist, the physiologist, and the philosopher, but at the same time bring in their train much in the way of valuable data utilisable in the future as the basis of comparison and generalisation, and as a most important contribution to the consideration of that great question—the extent and character of the profound changes wrought by human action on the physical and organic conditions of the globe.

And since from the commercial or non-scientific standpoint the white man has been so successful in his merely aggressive relations† with the Australian fauna and flora, it is worth while briefly considering the more important agencies which *pari passu* have been endeavouring to deal with the scientific side of this great problem; and which by their efforts to add to a scientific knowledge of the flora and fauna as a whole, have yet, on the lines so admirably laid down in Mr. Bentham's address, been preparing the way in the future for the devising of mitigating or remedial measures

* For twenty-five years after the foundation of the colony (in 1788), the settlers on the mainland were confined to the little patch of coast bounded by Port Stephens on the north, Jervis Bay on the south, and the Blue Mts. on the west. It was the successful attempt of Wentworth, Lawson, and Blaxland to cross the Blue Mts. in May, 1813, under stress of drought, that opened the way to the immense pastoral lands of the interior. Within the last thirty years the opening up of the country by railways has given a great impetus to settlement. In 1863 the number of sheep in New South Wales was 7,790,969; in 1891 the number was 61,831,416, according to the official records.

† It is not merely that man has disturbed the old relations of the members of the fauna and flora *inter se*, or that he has been so successful in elbowing them aside to make way for himself, his flocks and herds, rabbits, and weeds, but some of his actions are intentionally and deliberately of a destructive character. In New South Wales alone in the year 1891 the sum of £46,795 was officially disbursed as payment of bonuses for scalps of so-called "noxious animals," namely [besides 20,262 wild pigs and 649,131 hares], 1,140,953 marsupials (kangaroos, wallabies, wallaroos, kangaroo rats, wombats, bandicoots, paddamelons, and opossums), 11,530 dingos, 3,502 eagle-hawks, 21,929 crows, and 871 emus. This does not include animals killed but not officially accounted for; and the sacrifice has now become an annual one. (*Vide* Coghlan, Wealth and Progress of N. S. Wales for 1892, pp. 381-382.)

which as the result of man's wholesale disturbance of nature's arrangements have begun, as they were bound to do sooner or later, to call for attention. And for the sake of simplicity we may confine our attention briefly to the zoological branch of the subject.

The existing knowledge of the Zoology of Australia is the result of about one hundred and twenty years' work contributed to by many hands and many minds. The rather meagre first-fruits in the way of material were obtained during Captain Cook's first voyage; but beyond specimens of the kangaroo and of Cook's Phalanger, and the Banksian collections of fishes and insects, which were handed over to Broussonet and Fabricius respectively, the direct zoological results were not of very great moment. The work really began upon the important and more representative collections obtained and sent to England by Surgeon White and his colleagues, who came out with Captain Phillip's expedition on the founding of the colony in 1788. From that time steady progress has been made, resulting in the present substantial accumulation of knowledge. It is not, however, our present purpose to dwell upon the history of the parent division of the subject, associated as it is with the names of such a galaxy of eminent European zoologists and comparative anatomists, past and present; nor, since the time of Commodore Wilkes' expedition (1838-42), have American naturalists been altogether unrepresented.

Our concern is rather with a collateral branch—the contribution to the sum total of recorded knowledge made by Australian workers; a factor in the general progress of knowledge which, unpretentious enough in its beginnings and long retarded in its growth by unfavourable conditions in its childhood, has only of late years attained to lusty youth, showing hopeful and definite signs of promise in the future. Early in the century, residents, in addition to collecting, began to make observations on the habits and economy of some of the more striking members of the fauna, such as the *Ornithorhynchus* particularly, or upon some of the more conspicuous forms belonging to groups in which the particular bent of their natural history tastes especially interested them; and the results of their investigations were contributed to European scientific journals, or they were incorporated in books of travel; sometimes, indeed, extracts from letters to scientific friends at home touching upon some particular phase of the natural history of the newly colonised country did duty for more formal contributions.*

By degrees as settlement progressed the numbers of those interested in intellectual pursuits generally began to increase, and Scientific Societies were formed in the three older colonies—in New South Wales the Philosophical Society of Australasia,

* Among these early contributors may be mentioned Mr. G. P. Harris, Sir John Jamison, Dr. P. Hill, Rev. J. McGarvie, T. Axford, Dr. G. Bennett, Lieutenants Maule and Breton, Mr. R. H. Lewis, Mr. A. H. Davis, Mr. T. Winter, and Mr. R. Gunn.

founded as early as 1821; the Tasmanian Society, founded in 1838; the Victorian Institute, founded in 1854, and the Philosophical Society of Victoria, founded in 1855, these two Societies shortly afterwards amalgamating in 1856 as the Philosophical Institute of Victoria, subsequently the Royal Society of Victoria.

The working zoologists in the colonies in these early days, however, were from the nature of circumstances never very numerous; and their work at first was more or less that of field naturalists, for their efforts in other directions were insuperably hampered by the want of books and of reference collections, as well as by want of leisure, and by their isolation. A distinct advance was made when at least a portion of their work came to be published locally, and when they began to compile local fauna lists, and still later, from about 1852, to attempt in the light of local knowledge in a small way to deal critically with already described species, and to work up groups which had previously not received attention, because, among other reasons, it brought the workers in touch with intelligent colonists with a taste for natural history living in other and favourable localities, whose interest was aroused, and who, through their desire to make local collections, their anxiety to see them worked up, and their readiness to communicate the results of their observations, were led to become valuable coadjutors.

Of the older Australian Scientific Societies* above-mentioned, the Tasmanian Society more particularly concerned itself with biology. It was also the first to issue a publication; and a very creditable production indeed, under the circumstances, the Tasmanian Journal is, the first Part of which was published in 1841. This contains, besides contributions from visiting naturalists and by others non-resident, two zoological papers which, as the first contributions by residents published by an Australian Society, deserve mention, namely, Dr. E. C. Hobson's paper "On the *Callorynchus australis*," and the Rev. T. J. Ewing's "Catalogue of the Birds of Tasmania." From 1856 the Transactions of the Philosophical Institute of Victoria began to include a fair proportion of zoological papers. The Philosophical Society of Australasia and its successors were not for some considerable time [until 1866] in a position to publish a Journal, nor among its members in the early days were there apparently many active biologists.

The rate of progress of the knowledge of Australian Vertebrata naturally has been more rapid than that of the Invertebrata, the larger and more conspicuous forms first claiming attention. Thirty years ago, even making full allowance for all that has been accomplished since, the knowledge of the Vertebrata was well advanced, a result, as regards the bulk of the terrestrial forms, largely due to the enterprise and

* A *résumé* of the histories of two of these Societies will be found in the Presidential Addresses of Mr. H. C. Russell, B.A., F.R.S., C.M.G., and Sir Robert Hamilton, K.C.B., LL.D., to the Australasian Association for the Advancement of Science at the Sydney and Hobart Meetings. Reports, Vols. I. and IV.

enthusiasm of John Gould, whose magnificent monograph on the "Birds of Australia" was completed in 1848, and that on the "Mammals of Australia" in 1863.

With the much more numerous orders and species, and on the whole smaller and less conspicuous individuals to be dealt with, the knowledge of the Invertebrata was relatively much behind, and almost all that had been done was the work of non-resident naturalists. Of the zoological papers up to the year 1860 published by Australian Scientific Societies, all but a few were concerned with the Vertebrata, the more important exceptions being the Rev. R. L. King's three papers on freshwater Entomostraca,* Mr. W. Swainson's observations on Australian Mollusca,† and the first and second of a series of contributions to a knowledge of Australian Polyzoa, continued up to the present day, by Dr. P. H. MacGillivray.‡

Entomology, which from the first had attracted the notice of European workers beginning with Fabricius, who in his Systema Entomologiæ (1775) described the Australian species in the Banksian Collection, had not been advanced by a single locally published original contribution from any resident naturalist. A work entitled "Natural History of the Lepidopterous Insects of New South Wales," by J. W. Lewin, a resident, had, however, been published in London as early as 1805; and several residents had contributed a few papers to European Journals later than this but prior to 1860.

The decade 1860-70 was a most important one in the annals of Australian Biology, especially in New South Wales, for it inaugurated the improved condition of things, which, thanks largely to William Macleay, continues to the present day. The mother colony, New South Wales, instead of being last in the race, now began to come to the front, and this in spite of such drawbacks as that at this time and even until 1883, the Sydney University, the oldest of the colonial Universities, was without a Medical School, and consequently took no account of biology; and that the total number of those in the colony with whom zoological pursuits were the serious business of life, and who held official positions by virtue of biological qualifications, amounted to one—the Curator of the Australian Museum, whom the exigencies of the time required to be, if the expression may be allowed, more or less a universal specialist. Within the period mentioned, the few old workers set to work with renewed activity, and a number of new workers entered the field; much of their work began to be published locally not merely under the auspices of Scientific Societies, but in the form of separate publications, such as Cox's "Monograph of Australian Land Shells" (1868), and Krefft's "Snakes of Australia" (1869), while

* Three papers in the "Papers and Proceedings of the Royal Society of Van Diemen's Land." Vol. II. Part 2, 1852 [1853], pp. 243 and 253: Vol. III. Part 1, 1854 [January, 1855].

† Three papers. Ibid. Vol. III. Part 1, 1854 [1855], pp. 36, 42, and 46.

‡ Two papers in Transactions of the Philosophical Institute of Victoria, 1859, Vol. IV. pp. 97 and 159 [1860].

Parts 1-3 of Scott's "Australian Lepidoptera and their Transformations" were published in London in 1864. Early in the decade too Professor McCoy in Victoria, and Mr. G. F. Angas of South Australia, began to publish important zoological papers.

From the date mentioned until the present day, in which Australian workers in proportion to their number have begun to undertake a fair share of the work to be done, the advance has been, with little interruption on the whole, steady and marked. Not only have the older Australian Scientific Societies outgrown their early troubles, but Scientific Societies generally have multiplied, and in most of the Colonies such as have asked for it are now in receipt of aid in some shape from the State on a more or less liberal scale, though subject to the periodically recurring exigencies of retrenchment, and not therefore of an absolutely permanent character. The three Australian Universities now include in their curricula the teaching of biology on modern lines. Government Scientific Institutions, such as, for example, the Australian Museum and the Department of Mines of New South Wales, by increased endowments—also subject to reduction in times of retrenchment—have been able to extend their purely scientific operations; while the successful inauguration of new Departments, such as that of Agriculture, with its scientific staff, are all contributing to the general advancement. And lastly, the scientific federation of the Australasian colonies in and through the recently established Australasian Association for the Advancement of Science fitly rounds off and completes the cycle of scientific agencies now at work in Australasia. All that can reasonably be desired in the way of organisation is now forthcoming. The pressing need of the time is an increase in the number of workers sufficient both to supply the places of the veterans who in the ordinary course of nature are ceasing from their labours and yet to provide a progressive increase in the total number.

Finally, as the net result of all the agencies hitherto at work, in the year 1893 to the Australian Fauna generally may perhaps be fairly applied the words of Dr. P. L. Sclater in his Presidential Address to the Biological Section of the British Association in 1875—words on that occasion restricted to the Vertebrata alone—who said: "That we know more of the fauna of Australia than of other English colonies in different parts of the world is certain."

Nor is it too much to say that no local efforts have contributed more to this general advancement of Australian zoological knowledge than the work accomplished, without aid from the State, by the Entomological and Linnean Societies of New South Wales, of each of which Sir William Macleay was at once the moving and the sustaining spirit. And as the Societies mentioned were largely the instruments in and through which he, at the same time sinking his individuality, elected chiefly

to work, and furnished the channels through which much of his munificent liberality began and continued to flow; and further, as apart from the necessary compliance with the legal forms requisite to give effect and permanence to his intended benefactions, he has left almost nothing on record except in connection with the operations of these Societies, it becomes necessary in further considering the subject in hand to touch briefly upon some of the more important features of their history.

With what might almost be called hereditary tastes, or at least with the influence and example of his distinguished relatives, and with the opportunity of access to the Macleay Collection and library, it is hardly surprising that sooner or later Sir William Macleay should have begun to take a warm interest in natural history, and more particularly entomology. What at the time might at first sight have seemed surprising—though his subsequent career has now dissipated any ground for surprise—is that even at this early period, at the very outset of his career as a working naturalist, he should have been possessed with the desire not merely to do some useful work himself and that for love of it, but to see and to encourage united and organised effort, and this without attempting to arrogate to himself any air of patronage, without any assumption of dictatorship, but rather in a spirit of comradeship—an earnestness of purpose, and a breadth of view which characterised him for the rest of his life.

The Macleay Collection passed to him by inheritance on the death of Mr. W. S. Macleay in 1865; but before this he had possessed for some years a small collection of foreign insects; and as the result of his own collecting he had both added to the Macleay Collection, and commenced an Australian collection of his own. In 1861 he began to accumulate material on a more elaborate and systematic scale; for in this year Mr. Masters went under Sir William's auspices on an extended collecting tour to Port Denison, then newly settled; and some of his early papers were based on the examination of this material. Mr. Damel, in like manner, spent twelve months in Fiji on a similar errand. Exactly how far and in what way the acquisition of the valuable collections so obtained may have helped on the formation of the Entomological Society of New South Wales, which was founded shortly afterwards, it is not now possible to determine.

On April 7th, 1862, a preliminary meeting of a few gentleman interested in entomology was held at Sir William Macleay's residence, when the desirability of founding a local Entomological Society was affirmed, and a committee appointed to draw up rules and make arrangements. The justification for such a step was to be found in the facts that two important zoological collections were domiciled in Sydney, that though a Scientific Society had long been in existence in New South Wales, little

or no attention had been paid to biology, and that up to date it had not issued publications though for a time the papers read before the Society were published in the Sydney Magazine of Science and Art (2 vols. 1857-59). There seemed to be a desirable opening, therefore, for a Society which should confine its attention to biology, and, as the number of members, especially working members, was not likely to be large, to one particular section of biology, and which should issue its publications at short and if possible regular intervals, instead of delaying the publication of papers until the annual volume was complete in itself.

The first formal meeting of the new Society was held on May 5th, at which rules were brought up for consideration and adopted; while at the June meeting, in addition to the reading of the first paper, there was an election of office-bearers and Council, Sir William Macleay being elected President, which post he filled for two years, subsequently becoming, and continuing for the remainder of the Society's career, Hon. Secretary. His two admirable little Presidential Addresses, which were suggested by the pressing needs of all local workers at that time, deal with the history of Australian Entomology, or offer words of advice and encouragement to those desirous of following up the study of insects, with the recommendation to such not merely to exercise themselves in identifying described species or in describing new species, but to make observations on the habits, metamorphoses, geographical distribution, anatomy, and economic importance, whether as friends or pests, of Australian insects.

The new Society seems to have started enthusiastically and for some time to have sustained its enthusiasm. For three years (May, 1862, to April, 1865)—the period covered by the first of the two volumes of Transactions published by the Society, the meetings were continued with only two breaks, the meetings for July and December, 1864, appearing to have lapsed. From May, 1865, to the end of 1866 there is no record of any meetings; four meetings appear to have been held in 1867, two in 1868, two in 1869, none in 1870, four in 1871, none in 1872, and one—the last—in July, 1873; the papers read at these meetings were issued in five Parts comprising Vol. II. of the Transactions, but, unlike Vol. I., it contains only papers, without any notice of the proceedings of the Society. And as the Society's minute-book was destroyed in the Garden Palace fire, no further details are now obtainable from official sources.

The number of members was not and was never expected to be large, the original members numbering twenty-eight, and those subsequently elected about twenty-five. From first to last the number of working members who contributed papers amounted to six—Messrs. H. L. Schrader, William Macleay, R. L. King, A. W. Scott, G. Krefft, and H. H. Burton Bradley; and their efforts were eventually hampered

by pressure of other duties and their ranks depleted by removals from Sydney to such an extent that a steady supply of papers could not be kept up; for they were all busy public or professional men who in such leisure moments as they could command devoted themselves to the study of natural history out of love for it, and with the desire to promote the welfare of their favourite branch.

Though all the aspirations of its founders were not fulfilled during its eleven years' existence, somewhat fitful towards the last, nevertheless the Entomological Society of New South Wales rendered real and important service to the cause of biology in Australia. By bringing together a number of gentlemen for the most part previously strangers to each other, and by arousing their interest it gave an impetus to collecting, to observation, and to the study of entomology generally not only within the colony of New South Wales but elsewhere, so that at the present time the votaries of entomology are to be found in every colony and outnumber those of any other branch.

Nor is there wanting a permanent and useful record of the Society's labours, to be found in the shape of two volumes of Transactions still indispensable to working naturalists in certain groups, and happily not yet "out of print" and therefore more or less inaccessible to those who most need to consult them, as is so often and so provokingly the case with some of the earlier Australian scientific productions. And on several grounds these volumes are worthy of notice. They—or at least the first of them which was published in five parts issued as follows: Part i. in 1863, Part ii. in 1864, Parts iii.-iv. in 1864, and Part v. in 1866—were the first scientific publications issued by a Scientific Society in New South Wales; they represent the first important contributions from local workers to a knowledge of Australian Entomology in which attempts were made to deal with large groups, or to work up exhaustively large collections from particular localities. In this way there received attention the *Pselaphidæ*, the *Scaritidæ*, the *Glaphyridæ*, the *Scydmænides*, the *Amycteridæ*, the *Anthicidæ*, and the *Byrrhidæ*; while important additions were made to the *Cicindelidæ*, the *Buprestidæ*, and the *Cetoniadæ*, and by Mr. Scott to the Lepidoptera. For the first time, too, there were brought into notice such interesting novelties as the remarkable gall-making Coccids of the subfamily *Brachyscelinæ*, a group which from the symmetry, extraordinary shape constant for each species, and in some cases large size of the galls resulting from their operations upon the Eucalypts more particularly, would attract notice among gall-makers of any group; the fly *Batrachomyia* which oviposits upon frogs beneath whose integument the larvæ partially complete their metamorphosis, and which when about to oviposit must take some considerable pains to find a suitable host as all the frogs known to serve as such are nocturnal in their habits; of the curious blind beetle, *Illaphanus*, Macleay, found under stones near Wollongong, and as yet not met with elsewhere; and of various species of Coleoptera

inhabiting ants' nests. And lastly mention must be made of Rev. R. L. King's papers on Entomostraca, of Mr. Krefft's on Australian Entozoa, and of Mr. Bradley's on spiders, the commencement of a short series on this group afterwards continued for a time in the Proceedings of the Linnean Society of New South Wales; these though not entomological have at least the sanction of usage in finding a place in the journal of a Society nominally devoted to entomological studies.

Further, the work of the little Society seems to have stimulated not only workers in other colonies, but workers in other departments of zoology, and in New South Wales publication. In 1867 the late Count Castelnau, then resident in Melbourne, communicated two lengthy and important papers entitled "Notes on Australian Coleoptera" to the Royal Society of Victoria. From 1862 and onwards date the first contributions to the Annals and Magazine of Natural History, to the Proceedings of the Zoological Society of London, or to the Ibis, of the late Gerard Krefft on Reptilia and Mammalia (1862), of E. P. Ramsay on Ornithology (1863), and of Dr. J. C. Cox on Conchology (1864); all of them, including Count Castelnau, members of the Entomological Society of New South Wales. In 1866 the Philosophical Society of New South Wales published the first and only volume of its Transactions, containing the papers, or a selection from them, read before the Society during the years 1862-65, among them being several biological papers by Messrs. Krefft and Ramsay.

And as on the one hand by unavoidable circumstances the entomologists were reduced in numbers, and as on the other hand among the ordinary members of the Society there were several naturalists, not however entomologists, who, though for a time they collected and exhibited their specimens at the Meetings, were becoming actively interested in groups outside the scope of the Society's operations, it became evident in course of time that for the zoological talent available in the colony a Society on a more comprehensive basis than a purely Entomological Society was what was wanted. The Entomological Society of New South Wales was therefore given up. And there has never been any reason to regret this course since the way was thereby opened for a successor less restricted in its aims and of a more enduring character.

In connection with the Entomological Society of New South Wales, it only remains to be said that Sir William Macleay, ably seconded by the Rev. R. L. King, B.A., was the largest contributor of papers, that for some considerable time the meetings were held at his residence, that he gave important support, financial and otherwise, to an extent which cannot now be ascertained, and that his influence and efforts were mainly instrumental in enabling the Society to attain as much success as it did.

On the extinction of the Entomological Society of New South Wales, though Sir William laid aside descriptive work for a time, he still carried on his collecting operations more enthusiastically than ever, the best possible evidence that the spirit in which that Society had been originated and carried on remained undaunted. Indeed, it was at this time, and about a year before the inauguration of the Linnean Society of New South Wales, that he determined, and began to carry out his determination, of extending the Macleay Entomological Collection into a general zoological collection—the beginning of the present Macleay Museum. It is possible that for some time he may have had such an idea in his mind, but the circumstance, trivial in itself, which settled this determination was apparently a very simple one.

In January, 1874, Mr. Masters, afterwards and still Curator of the Macleay Museum, accompanied Sir William on a collecting visit in search of insects to the neighbourhood of Wagga, and on arrival he called on a local collector with whom he was in treaty for the purchase of some skins of birds frequenting the district, and took delivery of the same. The skins were in first rate condition, and when Sir William saw them he was much taken with them, and while the inspection was proceeding he said that he thought it would be a good thing to commence a general collection, and he offered to take the bird skins off Mr. Masters' hands. The result was that he became the possessor of them, and he made them the first addition to the entomological specimens to the acquisition of which he had previously exclusively confined his attention.

The correctness of this information, supplied by Mr. Masters in reply to an inquiry on the part of the writer of this article as to whether he could remember any circumstances which led to Sir William's extension of the entomological collection into a general collection, was amply corroborated by subsequent reference to a note-book of Sir William's in which during the years 1874-76 he kept a detailed account of the additions to his collections both by purchase and donation, and of the collections sent to his scientific correspondents in other countries, for it was then found that under the head of "Macleay Museum" the first entry was: "A. Bird skins purchased at Wagga on 8th January, 1874," with a list of the twenty-nine species represented. Succeeding this one, records of other purchases, at first chiefly of birds, follow rapidly. In the same book also were found two letters, unaddressed and undated, relating to the purchase of specimens on a large scale, from internal evidence evidently copies of the originals sent to European dealers, in one of which he says, "I have hitherto confined my attention entirely to the Articulata, but it is now my intention to make my collection as perfect as possible in all branches of the Animal Kingdom. It is therefore very likely that I may become a very large purchaser from you."

Shortly afterwards a special visit was made to Sir William's station for the purpose of general collecting and with good results. In the meantime the services of Mr. J. Brazier, the well-known conchologist, were enlisted in the good cause, and in a small vessel (the *Peahen*) chartered by Sir William he superintended dredging operations at various localities on the coast, which resulted in a substantial commencement with the Mollusca and other marine forms; while Sir William and Mr. Masters dredged and collected extensively Port Jackson forms. Mr. Spalding, too, about this time, went on a year's collecting expedition at Sir William's instigation to the Endeavour River and Cleveland Bay, and some of the acquisitions obtained by him were dealt with in some of the earliest papers contributed by various writers to the Linnean Society of New South Wales, which was founded shortly afterwards.

The earliest record of this Society is a notice of a preliminary meeting of gentlemen interested in natural science held in the board room of the Public Library, Sydney, on October 29th, 1874, to be found in the Sydney newspapers of October 30th. At this meeting it was resolved to form a Society under the name and title of the Linnean Society of New South Wales, whose object should be the cultivation of natural history in all its branches; the amount of the annual subscription and the number of office-bearers and Council were decided upon; it was also agreed that William Macleay, Esq., Sir William MacArthur, Captain Stackhouse, R.N., and H. H. Burton Bradley, Esq., should be invited to accept the offices of President, Vice-President, Hon. Secretary, and Hon. Treasurer respectively. A committee consisting of the President elect, W. J. Stephens, Esq., and Dr. Alleyne, was appointed to draft rules, to make inquiries respecting a suitable room for the Society's use, to draw up and issue circulars giving full information as to the nature and aims of the Society, and inviting the co-operation of all interested in the study of natural history. On November 4th the adjourned meeting, called by advertisement in the daily papers, took place, when the proposed rules were read and adopted. Still later (on January 13th, 1875), a meeting for the election of the office-bearers and Council was held; and on January 25th the first formal meeting for the reading of papers and other scientific business took place in a room which was rented for the Society's use in Lloyd's Chambers, 362 George Street, where the meetings continued to be held for some months.

In the meantime Sir William Macleay had decided on an important step, namely, a personally superintended collecting expedition, fitted out at his own expense, to the N.E. coast of Australia, Torres Straits and New Guinea. A period even so short as eighteen years has made a very material difference in the character of the shipping frequenting Port Jackson. A handy little steamer, eminently fitted for such a trip, could nowadays be obtained without much difficulty; in 1875 such a craft was not so easily to be found just when wanted. On February 27th, 1875, Sir William

therefore completed the arrangements for the purchase of the barque Chevert, of 313 tons register; he had the vessel fitted up in a suitable manner, and by May 18th following, a steam launch and the necessary stores having been shipped, the vessel was ready for sea, and sailed the same day for Somerset, Cape York.

The following outline of the voyage (treated as if it were a continuous narrative) is extracted from a lengthy account, founded upon the records of his private journal, contributed by Sir William to the *Sydney Morning Herald* of October 11th, 1875* :—

The barque Chevert sailed from Port Jackson on Tuesday, 18th May [1875], with a crew of twenty men, which, with the doctor, four zoological and two botanical (afterwards increased to three) collectors, Captain Onslow and myself, made up a total of thirty souls. The ship was fitted up chiefly with the object of making collections in all branches of Natural History in the islands of Torres Straits and in New Guinea. At the same time I was quite prepared, if opportunity offered, to have given up a considerable portion of my time to the geographical investigation of the as yet *terra incognita* New Guinea.

Our first stopping place after leaving Sydney was Percy Island. There we anchored for a night [May 29th]. The island is rough and barren, and I should say very rarely visited by natives, but the shores teem with fish. We caught with the seine, on as mall sandy beach on the north-west side of No. 2 island, garfish, pike, whiting, &c., of a size which would be looked upon as wonderful in Sydney, while, with hook and line, from the ship at night, a number of different species of large *Sparidæ* were captured.

The Palm Islands, our next stopping place [June 1st-4th], are lofty and precipitous. They seem to be entirely of granite formation, yet the soil is good, and the vegetation of the richest tropical luxuriance. We found the roughness of the ground and the density of the vegetation great bars to our rambling, but, notwithstanding, during our stay here we added very considerably to our collections. Here we saw a few aborigines, all men; they had probably come over from Cleveland Bay, and were the very worst specimens of the Australian race I have seen—short, thin and dirty, without a rag of clothing of any kind. Their canoes were small hollowed-out logs, with an outrigger.

On the 4th June we left the Palm Islands, and anchored off Brooke Island, and on the following day we found a very snug anchorage on the north-west side of the North Barnard Isles. Our object in calling here was to get a species of *Ptiloris* peculiar to the island, and Mr. Masters was so fortunate as to procure a fine male and two females in the course of the afternoon. Our next stage was Fitzroy Island [June 6th]. Here we got a few birds, but, as at Palm Island, it was most difficult to penetrate the dense brush with which it is clothed.

On the next day we anchored early off a low wooded sandbank, marked on the chart as Low Wooded Isle. It is surrounded by an extensive coral reef—the first coral reef seen by most of us—and, as may be supposed, almost every one left the ship that afternoon for a run on the reef. I was myself rather disappointed in my first impression. I failed to see the great beauty and variety of colouring which is said to be the characteristic of coral reefs, and is, I have no doubt, of the outer Barrier Reef; but I was very deeply impressed with the wonderful variety of life with which it abounded. The whole reef was literally teeming with life—fish in great variety, crustaceans, echinoderms, including several species of bêche-de-mer, corals and annelids.

Our next anchorage was off Turtle Reef, opposite the Endeavour River [June 8th]. We passed this day, though at some distance, a belt of country on the mainland, which looks very promising.

* The remaining portion of the article has been omitted to save space, more particularly as it has reference to places and matters which, though interesting enough at the time, have since then been fully dealt with by more recent writers.

On June 9th we anchored at No. 4 Howick Group.

Our next stage was Flinders' Island. The land along which we passed was very rough and rocky; indeed, Cape Melville is the most wonderful conglomeration of rocks I ever saw.

Two days more took us to Cape Grenville [June 12th]. On the first of these we anchored off Cape Sidmouth, on the next near the Piper Islands. Our stay at Cape Grenville of five days was occupied on the part of the crew in refilling our empty water tanks, and on that of the collectors by doing what they could in their respective lines. Our success, however, was not very great. The weather was stormy and wet, and the country was the most arid and barren that can well be imagined.

On June 18th, the morning after we left Cape Grenville, we sailed through the Albany Passage, past the settlement of Somerset, and cast anchor about a mile and a-half beyond it in Mud Bay.

The Chevert was detained here until the 26th June, awaiting the arrival of the mail from Sydney. The time was employed constantly in collecting, but without any very marked success. The country near the settlement is densely wooded, but of the poorest possible character.

Our course after leaving Australia was due north to Warrior Island, a distance of 60 miles; but, as we were late in getting away from our anchorage, we were compelled to drop anchor the first night under the lee of Sue Island, one of three low wooded islets lying about five miles apart, known as the "Three Sisters," the others being named Bet and Poll. The most notable thing about Sue Island was that the anchorage ground we were on, about a mile north-west of the island, seemed to be perfectly covered with masses of the young pearlshell, and we subsequently found the same to be the case off Bet Island. On the following day we anchored off Warrior Island—a mere sandbank of small extent, and without vegetation, but the birthplace and home of the strongest, most numerous, and most adventurous of the races inhabiting the islands of Torres Straits.

On Tuesday morning, June 28th, we proceeded on our course to New Guinea, making for the mouth of the Katow River. Our direction was nearly due north, the wind was fair though strong, and the great Warrior Reef, which stretches almost without a break from Warrior Island to the coast of New Guinea near Bristow Island, effectually sheltered us from the heavy sea to which we would otherwise have been exposed. We anticipated, therefore, an easy run of a few hours to the Katow, and our pilot, Tongatabu Joe, assured us that the way was clear and open. We found ourselves, however, soon after the shore of New Guinea had become distinctly visible and while we were still nearly twelve miles from land, involved in a mass of reefs in little more than two fathoms of water, and it took five days of unremitting work on the part of the captain in sounding and buoying our way, two miles at a time, before we finally dropped anchor about one and a-half miles from the mouth of the Katow River and village of Mohatta.

Next morning [July 3rd] we were visited by two canoes, with about twelve men in each. In one was Maino, the head man of the village of Mohatta; in the other Owta, the head man of a village three miles further west, and just visible from the ship. They came on board with the utmost confidence.

Shortly afterwards we landed, to the number of twenty-two, in the fishing and surf boats, and were received at the village by the elder members of the tribe, seated in a circle upon a large piece of new matting.

On our first day ashore we walked for a little distance along the beach, attended by all the youngsters of the village, who seemed quite delighted at our visit, and kept supplying us with grasshoppers and every living thing they could pick up, with the greatest diligence.

A few birds were shot, but Mr. Masters found all attempts to penetrate the jungle ineffectual.

The following day I determined to attempt the navigation of the river, and accordingly at an early hour a party of twenty, including the captain, left the ship in the steam launch and surf boat, and after calling at the village and getting Maino and Owta to accompany us, we commenced our first essay to penetrate into the interior of the country. The Katow, at its mouth, is about 200 yards wide; it very soon, however, narrows to about 60 yards, and it was not more than 30 yards wide at the highest point we reached. For the first two miles we passed through a dense forest of mangrove, but beyond that the margin of the river was closely lined by a very beautiful palm, which raised its huge frond-like leaves right from the surface of the water to a height of nearly 50 feet. Behind these there was the lofty and interminable forest, excepting where occasionally a break in the dark mass showed a banana or taro plantation. The day was fine, the view on some of the reaches was very lovely, everything—trees, birds, &c., were new to us,—we were progressing most favourably, and were in great spirits, when we were stopped by a tree of great size, which had fallen or been felled, across the river. We had then ascended the river about eight or nine miles, and as we were in a fine stream of fresh water, three fathoms deep, we were unwilling to return without an effort to overcome the obstacle. Our tomahawks, however, were quite unequal to the task, and we were, after two hours' delay, compelled to turn back, with the intention of making another attempt the following day with suitable axes and cross-cut saws.

A party was formed the following morning [July 9th], which I was prevented by illness from joining, to ascend the river again and remove the obstruction, but despite axes and cross-cut saws, the obstruction remained immovable, and the boats were compelled to return.

Having thus failed in my effort to get inland by means of the river, and any progress by land being utterly impossible, I saw that it was of little use remaining longer at Katow. Birds were plentiful, but could not be got at. Crocodiles were abundant, but I had got two and wanted no more. Insects were few and fish were very scarce indeed. I therefore, on Saturday, July 10th, after about eight days' stay, gave instructions for a move as soon as possible. It was not, however, till the 17th that we again cast anchor off Warrior Island. The working the ship out from Katow into clear water was more difficult than the approach, in so far that, in addition to the sounding and buoying of every inch of the way, we had on our return a south-easterly gale directly against us. Darnley Island, on account of its reputation as a convenient watering place, was our next destination, but though the distance was short, the weather was so tempestuous, and the wind so unfavourable, that we did not reach it till the afternoon of the 31st. The intermediate time was spent at anchor off the islands of Dungeness, Long Island, Bet, Sue, Cocoanut, and York Islands, and at some of these we found the Torres Straits pigeon so plentiful that we were enabled to shoot enough for food for the whole ship's company.

We remained at a very snug anchorage in Treacherous Bay, on the north side of Darnley Island, for a fortnight, waiting for letters from Cape York. Our success in dredging was very great, and altogether our time was not misspent.

On Friday, August 13th, we left Darnley Island for Hall Sound, on the east side of the Gulf of Papua, and, as we were informed we would find a very heavy sea crossing the gulf, I was reluctantly compelled to leave the steam launch behind in charge of the missionary.

It had been no part of my intention originally to visit that part of New Guinea, but I found, upon our escape from the difficulties of Katow, that the captain was most averse, so long as the strong south-east trade wind continued, again to approach such a dangerous coast, and he positively declined to take the ship in towards the mouth of the Fly River before the month of October. There was nothing left for me, therefore but to try the east side of the gulf. It took us five days to get to Hall Sound, calling on our way at Bramble Cay, the breeding place of innumerable boobies, noddies, and terns.

We found, as we had been told, a very heavy sea in the gulf, and unfortunately, when we got within thirty or forty miles of the coast of New Guinea, the wind went down, but the sea did not, and we were tossed and rolled about for two days within sight of our haven, but powerless to reach it.

Yule Island forms the sea face of the sound, and the opening on the north side between the island and the mainland is merely a shallow sandbank. We dropped anchor [August 19th] close to the north-west point of the island, opposite Mr. D'Albertis' residence, which we could see perched on the side of a clear hill about 100 feet above the water.

We remained at our anchorage off Yule Island until Thursday, September 2nd, during all which time we were employed collecting. One attempt was made to penetrate inland. We ran up a river, named by Captain Moresby the Ethel, for 10 or 12 miles and camped out for a night on its banks; but we were, as at Katow, stopped by timber, and it was very apparent that we could not hope to reach the mountains by that channel. We got many handsome and valuable birds during our stay here, averaging in number of specimens from twenty to thirty a day, among them some fine specimens of *Buceros* and one of the magnificent crested goura. We saw plenty of the plumes of birds of Paradise among the natives, but shot none. Our success in other respects was fair. Mr. Brazier secured a goodly lot of land shells; Mr. Spalding got a dozen specimens of the very rare *Batocera Wallacei*, and a snake belonging to the genus *Liasis* was secured, of the length of 14 feet. I was disappointed, however, in not getting specimens of the cassowary and tree kangaroo. On leaving Hall Sound it was my intention to visit Redscar Bay, about 24 miles to the east-south-east, as there were still three weeks to run of the time which I had fixed upon for my return to Cape York. But on finding the wind unfavourable, and that we might be a day or two doing what I hoped to do in three hours, I gave instructions for an immediate return to Darnley Island to pick up the steam launch *en route* to Cape York. On Wednesday, the 8th September, the Chevert dropped her anchor in her old anchorage near Somerset, and my expedition to New Guinea came to a close.

Except as regards seeing something of the interior of New Guinea, Sir William fairly carried out his intended programme. The following extracts from his speech at the banquet tendered to him on the eve of leaving Sydney already referred to, show in what direction his hopes lay in regard to the matter of New Guinea.

"I intend," he said, "in the first place to visit the large delta on the western side of the Gulf of Papua, which consists either of numerous mouths of one river, or the mouths of numerous rivers. At all events, there can be no doubt that the delta is of enormous extent, and is probably formed at the outlet of the rivers from the largest and least known part of the island of New Guinea. I hope that by means of a steam-launch which I shall take with me, and which will be so fitted out that it would be utterly impossible for the natives to do any injury to those on board, to penetrate some distance, and be enabled to see what the interior of New Guinea is made of.

"If I can manage to get up the Fly River, for instance, the attempt to explore which thirty-five years ago failed on account of the hostility of the natives, I shall accomplish a great work. I hope to do that, for I believe a great change has come over the natives, who, within the last few years, have had frequent intercourse with pearl traders, and in whose territory missionary settlements have been formed. Missionaries were received in the most kindly way; and, as far as I can learn, hostility by the natives has in a great measure ceased."

These hopes, as we have seen, were frustrated by untoward circumstances. The subsequent experiences of the Rev. S. Macfarlane and Signor D'Albertis in the

Ellangowan in November-December, 1875, and of D'Albertis in 1875-77 in the Neva, the steam launch placed at his disposal by the New South Wales Government, demonstrated the importance of the Fly River as a route to the interior, and showed that hostility on the part of the natives was a less serious obstacle than at the time of Captain Stokes' visit. No doubt Sir William was disappointed in the non-realisation of his hopes; but the primary object of his cruise was not geographical exploration, and it is unfair to judge of results from that standpoint alone, more especially since any geographical results which, under more favourable circumstances and with a longer time at disposal, might have been obtained were only postponed for a short time, for Signor D'Albertis had been resident on Yule Island nearly six months when the Chevert arrived there, and the Revs. S. Macfarlane and W. G. Lawes had already commenced active operations in connection with the London Missionary Society.

In other respects certainly Sir William Macleay was not disappointed with the results of his cruise, nor did he ever begrudge the money he spent in connection with it. Of the zoological acquisitions, which it was his chief object to obtain, he says:—

"Altogether I have succeeded in getting together a vast and valuable collection—a collection which, considering the short time at my disposal, seems wonderful, and which affords undoubted proof of the industry and zeal of my staff of collectors. For, it must be remembered that, though the full time of my intended absence from Sydney has expired, the actual time available for the purposes of the voyage was much less than I calculated on. The Chevert, though a good, dry, and comfortable ship, was unable to sail against the wind, and it was so constantly against us during a great part of the expedition, that I do not think we had more than sixty days for collecting during the five months' cruise."

Nor is the gain resulting from the voyage of the Chevert to be measured simply by the extensive collections obtained. In one of his Presidential Addresses, the late Professor Stephens, referring to this subject, gives it as his opinion that "it was unquestionably to that expedition and its results that the Linnean Society of New South Wales owes its early and vigorous growth." This, however, was not all. The voyage of the Chevert, besides adding to his knowledge of Australia, brought under Sir William Macleay's notice the exuberant animal life of the tropics, thereby stimulating anew his interest in general zoology; and this, together with his desire to see his collections worked up, not only confirmed and strengthened his wish to promote the welfare of biology, but helped to lead up to a further unfolding of plans to that end.

There are several events in the history of the Linnean Society of New South Wales to which further reference must be made because they brought out in a characteristic manner the quiet and undemonstrative but effective way in which Sir William set about his work, and the unostentatious liberality of his dealings with the Society, and this in the face of difficulties and complications which quite unexpectedly arose.

For several years after its successful inauguration the Society had no settled home sufficiently commodious to allow of the expansion of the library, or of the holding of meetings. In 1881, after the large Exhibition building known as the Garden Palace erected in the Botanical Gardens had served the purpose for which it was primarily intended, and its retention had been decided upon, the Society, in common with the Technological Museum, and certain Government Departments, was, by permission of the Government allowed to take up its quarters in the vacant building, and two commodious rooms were placed at its disposal. The publications which the Society had received from Corresponding Societies, or as donations from private individuals, previously inaccessible for want of room, were thereupon made available to members. Sir William very soon largely added to the books acquired in this way, partly by two valuable gifts, one of 600 volumes, and partly by denuding the shelves of his own library and depositing on loan books to the value of £950; several microscopes, in addition to a valuable instrument by Ross which he had already presented to the Society, and cabinets of slides were likewise placed at the disposal of members; and an extensive herbarium of Australian plants collected and lent by the late Rev. J. E. Tenison-Woods added an additional attraction to those interested in botanical studies. Further in the months of October-December, 1881, under the auspices of the Society, and by arrangement with Sir William Macleay, a course of twenty lectures on Zoology was delivered by Mr. W. A. Haswell, M.A., B.Sc., without fee or charge open to all desirous of attending—the first time such a comprehensive and instructive course had been brought within reach of Sydney students or of the public.

This chapter of the Society's history, just when everything seemed to be promising so well, was abruptly closed in a most unexpected manner by a disastrous conflagration early on the morning of September 22nd, 1882, which in a very short time reduced the Garden Palace and its contents to a heap of ashes.

The Linnean Society of New South Wales lost not only everything which Sir William's generosity had provided, but it suffered the irreparable loss of its official records, and the reserve stock of the first six volumes of the Proceedings, numbering more than 1000 copies in the aggregate, together with about 700 copies of Parts i. and ii. of Vol. VII. which had recently been delivered by the printer; the total loss being estimated at £3000.

This unexpected and disastrous blow might well have crushed the hopes and damped the ardour of Sir William and those associated with him in the management of the Society's affairs; it might even have been accepted as an omen that its resuscitation had better not be attempted, or at least were more wisely postponed. Special meetings of the Council of the Society were, however, at once called, and temporary

arrangements were made for carrying on affairs; and encouraged by the sympathy which the disastrous event evoked on all sides, and by the measure of success so far attained by the Society, of which the six complete volumes of Proceedings already issued were tangible proof, Sir William and his colleagues set courageously to work at what might be called his third attempt to set an Australian Biological Society permanently on its feet.

For some time the homeless Society was allowed by the courtesy of the Trustees to hold its scientific meetings in the Board Room of the Public Library, a room in a house in Hunter Street serving as an office; but a few months later Sir William in his private capacity rented a centrally situated and commodious house in Phillip Street, which he fitted up, and which thereupon without any formal announcement or ceremony the Society proceeded to occupy, and continued to do so with great comfort for a period of more than two years. In the meantime Sir William in an equally unostentatious manner had taken in hand the matter of replacing the library, and by his supplementing the effort which the Society itself made in this direction by the initiation of a special fund, the new library soon began to assume something like the proportions of that which had been destroyed.

Meanwhile the question of a permanent home for the Society had been mooted and discussed, and Sir William offered that if a city site could be secured he himself would bear the cost of the erection of a suitable building. Several sites were inspected, but the current rates of purchase demanded for centrally situated land were so enormously high, the sum of £5000 being asked for the small available area that appeared most suitable, that it at once became evident that without becoming hopelessly involved in debt the Society—which never at any time in its history has had a membership of two hundred effective members, and a Society which has little in the way of inducements to offer to any but those possessed with an active interest in, or a taste for, natural history, or with a desire to help in fostering any intellectual pursuit, not it must be confessed a very large proportion of a young community—could not but come to the conclusion that its resources were unequal to the strain of the contemplated purchase. Sir William thereupon came to the rescue with an offer of both land and house at Elizabeth Bay; an offer which the Council could not but gratefully accept. Early in 1885 under Sir William's directions the project was put in hand, and in October of that year the building was completed. The land, which with the building were subsequently conveyed to the Society by deed of gift, has a frontage of 179 feet to Ithaca Road, formerly Bay Street, by a depth of 120 feet fronting Billyard Avenue: it is but a few yards from the water's edge of Elizabeth Bay, and in fact on the north side the boundary would almost coincide with the old high-water mark before the erection of the present sea-wall and the resumption of a small intervening area. It is part of the fine old garden to the attractions of which

both Mr. A. Macleay and Mr. W. S. Macleay in turn took so much delight in adding; after the death of the latter it was partially subdivided to meet the increasing demand of room for the expansion of a rapidly growing city and suburbs.

The building, known as the Linnean Hall, erected by Sir William, is a substantially built commodious brick building of unpretentious appearance, 80 by 40 feet; the rooms, lofty and well ventilated, comprise an office, storeroom, a meeting room and library, 40 by 40 feet, the ceiling and roof supported by six columns with enriched capitals, ample provision being made for bookshelves; and a laboratory, 40 by 20 feet, in which students desirous of carrying on investigations with the library at hand or in proximity to the sea, can by arrangement be provided with work tables.

On October 31st, 1885, the members of the Society were entertained by Sir William at luncheon in the new Hall, whereupon, after briefly sketching the circumstances which had led up to the event of the day, without, however, any allusion to his own share in the expenditure of time, energy, or money in carrying out the past work of the Society, he in a few simple words dedicated the building to the service for which it was intended. As this was the only occasion on which Sir William ever publicly alluded to any of his benefactions to the Society we may give his own words :—

"The occasion which has brought us together will justify, I think, a few remarks from me on the past and present of this Society, and its prospects of future usefulness. The past may be briefly dealt with. The Society was first formed chiefly through the exertions of Captain Stackhouse, R.N., about the beginning of the year 1875, so that it has now been ten years in existence. . . . But during all this period in which we have been, it may be said, building up the scientific reputation of the Society, we have been labouring under serious difficulties of several kinds, but none so great as the want of sufficient space to meet our requirements. For the first year or so of the Society's existence it occupied an upstairs room in Hunter Street, extremely inconvenient and difficult of access. It then, for about three years, held its meetings in a room in the Public Library, by the permission of the trustees of that institution. The next move was to very excellent and commodious apartments in the Garden Palace, which the Government of the day had most liberally placed at our disposal. Up till then we had had no room for books or anything else, and the scientific publications sent to us from foreign Societies were packed away in cases, and were literally inaccessible. But when we found ourselves in possession of the ample space allotted to us in the Garden Palace, we were at once enabled to enter upon the course of usefulness which was the original intention of the founders of the Society; and we had collected a large and valuable library of works on scientific subjects and had completed the first series of lectures on natural history, open to the public, when the destruction by fire of the entire building rendered us once more homeless and destitute. . . . For some months after the fire we were again accommodated at the Public Library, and then for a few months we occupied a small room in Hunter Street, but in both these places the space at our disposal was so limited that we were precluded from making any attempt to again get together a collection of books. Subsequently we obtained possession of a convenient and central house in Phillip Street, in which the noise of the tram-cars was our only serious disadvantage, and since then, that is to say, during the last two years, we have, though not overburdened with space, been enabled to invite contributions to the library, and the result, I am glad to inform you, is that we have now a large and excellent reference library, comprising

over 5000 publications on scientific subjects. The necessity, however, for more room, and I may add less noise, has induced me to build the edifice we are now assembled in, which I beg to present, such as it is, to the Society for the period of 89 years, the unexpired term of my original lease of the ground for 99 years.

"And now, having got to this point in our history, when I hope that all difficulties have terminated, and we may look forward to a prosperous future, it would be well to review the objects with which the Society was founded. Our rules state that the Society is 'for the promotion of the study of natural history in all its branches.' Few people, I suspect, are aware of the wide significance of that sentence."

In connection with the Linnean Society of New South Wales it is only necessary to mention further the gift by Sir William during his lifetime of the sum of £14,000 by way of endowment, supplemented by a bequest of £6000 towards the same object. Virtually, however, the actual endowment dates more or less from the commencement of the Society, for though Sir William kept the principal in his own hands, yet his liberality found an outlet each year for more or less of the annual interest on the amount named. And in addressing the host on the festive occasion referred to above, Professor Stephens neither overstated Sir William's liberality to the Society nor failed to express the sentiments of the members of the Society, and especially of those who had been officially associated with Sir William Macleay in the conduct of the Society's affairs, when he said :—

"In the brief history of the operations of the Linnean Society of New South Wales, which you have just laid before its members, and your notice of the inconveniences and even disaster under which its work has been hitherto maintained, I observe a serious omission of important facts. It is quite true that the Society was in the first instance confined to a very indifferent lodging, that our affairs were improved by the permission of the trustees of the Free Public Library to occupy for the purposes of our meetings a room in that establishment, and that our possession of excellent quarters in the Garden Palace was only terminated in a fatal conflagration. You have forgotten, however, to state that since that misfortune you have lodged the Society at your own expense, providing for its use in the first place an office in Hunter Street; and, secondly, a commodious house in Phillip Street, in which we have been for two years exceedingly comfortable, and which you cease to place at our disposal only because you have now completed the building of this spacious and admirably planned Palace of Science which you have this day presented to us. You have also neglected to inform us of the fact that you have yourself supplied the salaries of the paid officers of the Society. That you have defrayed by far the greater portion of the cost of the Society's publications, and that you have purchased and presented to the Society two inestimable collections of scientific books and records, one unhappily doomed to perish in flame, the other, I trust, likely to remain safely and conveniently arranged in this house for the continual use and advantage of the Society. One further benefit you have conferred upon all members, present and future, and I may add, upon the whole of Australia, in the incorporation of the Society by Act of Parliament. It is to you that the country owes the establishment of a new and permanent institution, founded, not for the sake of any pecuniary, social, or political advantage to its members, but for assistance to students in their labours to promote knowledge, for the progress of this community, and for the welfare of humanity.

"There is a malignant old proverb which advises us not to look a gift horse in the mouth. Your horses, however, require no examination. They have been given with a warranty, a warranty absolute and perfect, which we all recognise with a kind of wonder, in the far-reaching and thorough-going character of your munificence. No higher guarantee for the soundness of your gift horses could be offered, and your

own delicacy and reticence prevent us from knowing, except on our own conjecture and estimate, how astonishing and prodigious your liberality has been. I purposely omit on this occasion any particular reference to the similar services which you have rendered to other institutions, and hasten, as President of the Linnean Society of New South Wales, to offer you a faint and inadequate expression of the feelings which animate our whole body. The Society entertains an ardent gratitude towards you—a gratitude which is not dulled, as gratitude may sometimes be dulled, by any affectation of beneficence, or any haughty or inconsiderate phrase or touch of manner in your acts of donation, but is, on the contrary, ever quickened by the freedom from vulgar ostentation and by the generous simplicity which specially characterise your behaviour towards the Society. You will, I hope—or rather, I am confident—accept these few words as an honest attempt to give some expression, however imperfect, to the sentiment dominant in every heart in this gathering of your friends and guests. In their name I thank you for your services as an active partner in their labours, as a wise legislator and officer in the management of their affairs, and a benefactor whose munificence would have made us feel a heavy burden of obligation, had it been attended with scantier courtesy, or with less emphatic kindness."

And just as during his lifetime he was a sagacious guardian of the Society's welfare, never tendering his all important aid in such a way as to make others think that they had nothing to do but stand by and admire his liberality, his policy, on the contrary, being rather to offer supplementary help in the most unostentatious manner possible only after he had waited to see what the enterprise and resources of the members at large were capable of accomplishing, so in his latest benefactions Sir William Macleay's intentions are evident enough. While on the one hand he wished to see the Society saved from the pinch of poverty which in the absence of any source of endowment is so calculated to sap the energy and hamper the usefulness of a Scientific Society, especially in a young country, or from being largely dependent for its usefulness on State patronage, so often apt to be paralysing in its tendency, he would not, even if it had been in his power, have endowed the Society with great wealth, recognising the stimulating necessity for individual effort, resulting in united effort, which alone would enable the Society both to maintain and promote its usefulness, and in the efficacy of which he was so strong a believer.

We may now revert for a moment to Sir William Macleay in the capacity of working naturalist to point out that the work begun so enthusiastically in 1862 was with few breaks steadily kept up until 1889, when failing health began to interrupt, and finally peremptorily put a stop to it. His work was necessarily of a pioneering and systematic character ; yet he was by no means a mere systematist whose sole idea was the multiplication of species, and nothing more. On the contrary, he clearly recognised the advantage accruing to a zoologist from residence in the country ; he was bent on overcoming, or at least mitigating, the almost prohibitive disabilities in respect of want of literature and of reference collections under which Australian workers in his day laboured, and to some extent still labour ; and he knew, too, that the systematist must precede the morphologist. The keynote to his work he himself gives in his first Presidential Address to the Linnean Society of New South Wales in 1876, when he says :—

"My position as President of this Society gives me no right to thrust my advice upon you, but I am desirous of giving assistance, in so far as my judgment approves, in contributing to the usefulness of the Society, and I claim to know to some extent how that can be best accomplished. I am convinced that we cannot do better in the present state of natural history in Australia than confine our attention to observing, cataloguing, and describing. . . . The reason why I recommend descriptive catalogues is because they are not only what are most required (our knowledge of the Australian Fauna [as a whole] being still very limited), but because any generalisation of, or deductions from, what we do know cannot be of much value with our present imperfect knowledge. . . . There is no better exercise for the student than the describing of new species, and there is certainly no better way of making himself useful to the workers in other spheres of natural history who have not the same opportunities of observation and comparison."

In this spirit his attention at first, as we have seen, was given wholly to entomology. The acquisitions in the department of general entomology obtained during the voyage of the Chevert, though numerous and a most valuable addition to the Macleay Collection, did not include many representatives of the groups of Coleoptera in which he was particularly interested, for he says—"the Coleoptera were upon the whole rare and difficult to get, though we managed to scrape together several thousand specimens," referable chiefly to the *Longicornia* and *Curculionidæ*.

The collection of lower vertebrates, especially of fishes, was, however, important. Of the fishes particularly he says that the collection was "of a most varied and interesting character, exceeding in point of numbers the collections made in those seas on any previous occasion," over one thousand specimens having been preserved. The desire to see his collections systematically worked up, and the wider interest in general zoology arising out of the experiences of the previous year (1874), decided Sir William, in the absence of any resident naturalist interested in these groups, to undertake the task himself, in the case of the fishes with the collaboration of the late Dr. H. G. Alleyne, of which the Teleostean forms were dealt with in two papers in Vol. I. of the Proceedings of the Linnean Society.

On the appointment of an ichthyologist in 1884 to the scientific staff of the Australian Museum, Sir William almost relinquished the study of vertebrates, and again devoted himself chiefly to entomology for the rest of his working days. In the meantime the interest aroused especially by the study of the Chevert material had led him subsequently to acquire and deal with important collections of fishes and snakes from various parts of Australia, and of fishes from the Solomon Islands and New Guinea; and in 1880 to commence a "Descriptive Catalogue of the Fishes of Australia,"* founded upon Dr. Günther's well-known British Museum Catalogue, which, from its comprehensive nature and the increased knowledge which its very publication had been largely instrumental in bringing about, had rendered possible the compilation of a work less bulky and costly, and more suited to the present day

* Proceedings of the Linnean Society of New South Wales. Vols. V., VI., and with a Supplement in Vol. IX. These papers were in 1884 re-issued as a separate publication.

requirements of local workers. In this connection also must be mentioned the enthusiastic efforts of the late Count Castelnau, the first resident naturalist to undertake systematic work on Australian fishes, and who in Melbourne—where he died in February, 1880—published his "Contribution to the Ichthyology of Australia," in nine Parts,* and supplemented these a little later, during a two years' residence in Sydney, by five additional papers, including an important "Essay on the Ichthyology of Port Jackson," published in Sydney.†

Steady progress in the advancement of knowledge of the two groups Lepidoptera and Coleoptera being ensured by the active interest in them evinced by naturalists in the different colonies, Sir William Macleay became seized with strong desire to see some of the other groups which had hitherto not received attention taken in hand in a similar manner by local workers, especially the Diptera, at which he at one time had serious thoughts of making a commencement, and indeed he made some progress with an introductory essay, as appears from an unpublished MS., entitled "The Australian Diptera," in which he says :—

> "It is not without reluctance that I undertake the task which I now impose upon myself, of making a descriptive catalogue of the Dipterous insects of Australia. Age, with its accompanying infirmities, is the reverse of a qualification for a work which necessitates a great deal of detailed examination of very minute animals. But I feel that, for some time at least, the work will not be done at all unless done by me; there is no one here at present at all likely to attempt it, and an application which I lately made for an entomologist [*i.e.*, a dipterologist] from England failed of success.
>
> "I have selected the Diptera in the first instance because I think them the most interesting and instructive. Notwithstanding their insignificant size, there are no insects man suffers so much from in his person and property; a knowledge of them, therefore, becomes a matter of importance even from a utilitarian point of view, while to the true student of nature who seeks after knowledge for knowledge' sake, apart from all considerations of mere gain, these marvellous little animals offer an inexhaustible field for original research of surpassing interest."

At a later date he himself made special provision for the elucidation of Australian Diptera by the appointment of a specialist, and he lived to see, with considerable satisfaction, some substantial progress made in this direction before matters again came to a standstill through his complete prostration by illness and the consequent withdrawal of the timely aid which alone made the undertaking possible.

Nothing, however, more clearly shows that Sir William was no narrow-minded specialist interested only in his own particular little group of the Animal Kingdom, his breadth of view and large-hearted interest in the welfare of natural science generally, and his earnest desire to see biology in all its branches steadily advance, than his attitude towards the subject of original research. For a number of years he

* Proceedings of the Zoological and Acclimatisation Society of Victoria. Vols. I. and II. (1872-73).

† Proceedings of the Linnean Society of New South Wales. Vols. II. and III.

was possessed with a keen interest in bacteriology, and he regularly and eagerly watched the progress in this department of knowledge as chronicled in the European and other Journals. In the first of his two Presidential Addresses to the Linnean Society of New South Wales, as long ago as January, 1876, as he did again in his Inaugural Address at the opening of the Linnean Hall in 1885, he points out that the object of the Society, as laid down in its published Rules, was the cultivation and study of all branches of natural history, and he emphasises the fact of "what a vast field of inquiry and study is included under the term natural history, as understood in its true meaning, and as taught by the illustrious man whose name we have adopted for this Society." While in his second Address in January, 1877, he says :—

"It will not, therefore, be supposed that I in any way seek to disparage what has been done if I proceed to point out what we may do, or that I think the study of any branch of natural history undesirable, because I may desire the field of enquiry to be widened. And there are a good many subjects to which I should like to see more attention paid. It has always seemed to me rather anomalous that a Society named after the most illustrious botanist the world has ever produced, should not have apparently a single working botanist among its members. I should like also to see more attention paid to the sciences of geology and palæontology.

"But there are some branches of biological science which have never yet occupied the attention of any of our contributors, and which are of more importance to mankind, and of more real interest to the man of science, than the study or contemplation of the most gorgeous birds, or the most perfect and beautiful flowers. I mean the study of the history, metamorphoses, and conditions of existence of those low forms of animal and vegetable life which are really the most formidable enemies of man, both in his person and property, and which are, I believe, only formidable because of our ignorance of their history.

"There is an immense field open here for investigation, and I am most desirous that this very important branch of biological science should receive the attention it merits from the members of this Society. And I would recommend this line of inquiry more particularly to those members who belong to the noble profession of medicine, as by the nature of their education and their opportunities of observation, they are of all others the best qualified for such investigations, . . . and surely to the medical man the acquirement of a knowledge of the source and cause of disease must be a nobler object of ambition than the highest skill in the empirical treatment of symptoms."

His hopes of seeing the subjects of botany, geology, and palæontology occupying the attention of the working members of the Society were, and not very long afterwards, amply gratified. The subject of bacteriology, however, still found a place in his thoughts, and in 1884 took practical shape by his anonymously presenting to the Society the sum of £100 to be offered as a prize for an essay "On the Life-history of the Bacillus of Typhoid Fever." This, however, led to no satisfactory result, and after being re-offered the following year, also in vain, at his own request the sum mentioned was passed to the general revenue of the Society. Still later, by his action Dr. Katz, who had recently arrived in the colony, began a series of bacteriological investigations, the results of which were communicated to the Society, and which in 1888 were interrupted by the demand for the services of a bacteriologist in

connection with the experiments with the microbes of chicken-cholera authorised by the Royal Commission appointed to inquire into schemes for the extermination of rabbits in Australia, and afterwards in connection with the bacteriological examination of the Melbourne water-supply.

About this time, feeling that the matter was of more than purely scientific importance, he cherished the hope of the permanent appointment of a Government bacteriologist; a hope which found expression in the following characteristic letter contributed under the *nom de plume* of "F.L.S." to one of the Sydney newspapers:—

"It has long been a matter of surprise to me that a Government which has displayed such a lavish liberality in protecting sheep from rabbits, not to mention scab, catarrh, prickly pear, Bathurst burr, and other ills and misfortunes which sheep are subject to, has never risked a very much smaller expenditure for the protection of human life from disease certainly preventable. Typhoid fever has now become a perfect scourge throughout Australia; the numbers of its victims are annually increasing, and they are generally the young and the strong; it is a disease known to be caused by a minute vegetable organism of the genus *Bacillus;* and it only requires a knowledge of the life-history of the microbe to find means to effectually stop the rapid increase of the disease, if not actually prevent it.

"A few years ago an effort was made by the Linnean Society of New South Wales to stimulate investigation in this direction, and for two years successively it offered a prize of £100 for an essay on the life-history of the bacillus of typhoid fever, but without result as far as original research was concerned. This, I think, was pretty clear evidence that the sum of £100 was insufficient to induce anyone to undertake an investigation necessarily involving much time and labour. But surely a Government which promises the huge sum of £25,000 for the destruction of rabbits can scarcely hesitate about spending the twenty-fifth part of that sum in the more urgent and important matters of checking disease and saving human life. It is with the intention of calling attention to this subject that I now write to you, and if I succeed (with your assistance, I hope) in rousing public interest, and inducing action on the part of the Government, I shall feel that humanity will benefit thereby to a greater degree than by the poisoning of a million rabbits.

"I believe that a prize of £1000 for an essay on the bacillus of typhoid fever, extending over three years, would be in all probability attended with most useful results; but it is not to be expected that any such essay would solve all, or nearly all, of the many doubtful points in the history of this microbe requiring solution. I would therefore much prefer to see two experienced and competent bacteriologists employed under the orders and control of the Board of Health, for the study of pathogenic organisms generally, at the discretion of the Board. It is certain that without assistance from the public funds it will be very long before the typhoid bacillus can be properly investigated. Scientific Societies have not the means to offer sufficient prizes; and medical men, who are from their biological education the best qualified people for such inquiries, are for the most part dependent on the practice of their profession for a living, and certainly cannot afford the time for lengthened investigations without fee or reward."

Finally, seeing no prospect of the immediate realisation of these hopes, and imbued with a sense of the importance of the subject, he began to entertain the project of making some provision for the endowment of Bacteriology out of his own means; and so enthusiastic was he about it that for some little time he contemplated doing it during his life-time, but subsequently changed his mind and

arranged for it in his will, dated in December, 1890, in the form of a bequest of the sum of £12,000 to the Senate of the Sydney University "for the foundation of a Chair or Lectureship in Bacteriology," subject to certain conditions set forth in the will and in a memorandum accompanying it. The conditions of acceptance may be thus stated: the Senate must accept the legacy for the purpose of providing a salary for a Lecturer or Professor in Bacteriology, who shall give both practical and theoretical instruction; the bequest must be used solely for the purpose mentioned, and the lecturer shall have no additional duties imposed on him; the appointment of the Lecturer or Professor shall be made by the Senate itself, and not delegated; and it shall be necessary for every student before being admitted to a Science or Medical Degree at the University to attend a six months' course of Bacteriology. The testator gives as his reasons for insisting on these conditions his strong conviction of the extreme importance of the study of Bacteriology both to the biologist and the physician, and his doubt as to the full recognition on the part of scientific men of this importance. These conditions are, as the testator intended they should be, of a stringent character; and because of his expressed uncertainty as to the views of the Senate on the subject, he directs his executors, in the event of the acceptance of the bequest by the Senate, to procure very distinct pledges from it on all the points mentioned; and if within one month after notification by the executors of the legacy the Senate shall not accept the conditions, or in the event of the Senate declining all or any of the conditions, he directs that the legacy to the University shall be void; and in that case the executors are empowered to hand over to the Linnean Society of New South Wales the aforesaid sum of £12,000 to provide a sufficient salary for the appointment of a bacteriologist whose duties it shall be to engage in bacteriological research in the Society's laboratory, and to give instruction to one or two pupils at the discretion and under the orders of the Council of the Society. The Senate having accepted the bequest on the conditions specified, the sum of £11,400, being the amount of the bequest after payment of legacy duty, has been paid to the University.

Of Sir William Macleay's estimate of the importance of fostering original research we may judge both by his encouragement of local workers and by his provision for future workers. During his life-time and under his auspices several specialists were able to carry on investigations, notably Dr. R. von Lendenfeld, who was interested more particularly in Cœlenterates, Dr. O. Katz, bacteriologist, and Mr. F. A. Skuse, who made a commencement with a revision of Australian Diptera; these, unless a particular piece of work was undertaken at his suggestion, beyond the stipulation that their work should be published in the Society's Proceedings, were left untrammelled in following out their own particular lines in their own way.

It was not, however, Sir William's object to attract workers from other fields so much as to see a love of natural history spreading among the rising generation in

New South Wales, especially when there was brought within reach the possibility of obtaining a scientific training according to modern methods without having to go abroad for it, by the addition of biology to the curriculum of Sydney University on the foundation of the Medical School in 1883. With a view of encouraging such, and in recognition of the fact that Australia offers few openings in the way of biological appointments and therefore little inducement to biologists unpossessed of private means to devote themselves to original work, notwithstanding the amount of work to be done and the very great interest attaching to a good deal of it, Sir William, after giving a life-interest in his residuary estate to his widow, bequeathed out of it upon trust to the Linnean Society of New South Wales the sum of thirty-five thousand pounds, to be invested *in perpetuo* and the interest thereof applied to the foundation of four research fellowships, to be called the LINNEAN MACLEAY FELLOWSHIPS, in the gift of the Council of the Society, and tenable by Bachelors of Science of the University of Sydney, the fellowships to be maintained for the following purposes and upon the following conditions, as set forth in the testator's last will. The fellowships are intended to encourage and advance research in natural science by enabling those who wish to continue their studies at the University or elsewhere after having completed the regular curriculum and taken a science degree to do so. Fellows must have taken a degree in science at the Sydney University, must reside in New South Wales and devote themselves entirely to research work, must be members of the Linnean Society of New South Wales and publish the results of their work in the Society's Proceedings. The subjects of investigation shall be all branches of natural history, biological and geological. The value of each fellowship shall be £400 per annum; and the appointment to a fellowship shall be for one year. The appointments to fellowships shall be made annually by the Council of the Society; but the testator states particularly that it is his intention and wish that Fellows shall be eligible for re-election from year to year so long as the Council is satisfied with the quantity and quality of the work done. If at any time fellowships be vacant but eligible candidates do not present themselves, then it shall not be necessary for the Council to make any appointments.

Sir William was aware that the fellowships were of greater monetary value than is usual under such circumstances; but on one occasion when, in conversation with the writer, that aspect of the matter was touched on, Sir William said that he had intentionally given them the assigned value because he wished to make it worth while for prospective Fellows to qualify themselves, and for actual Fellows to exert themselves enthusiastically enough to maintain their positions.

The collections which in various ways Sir William Macleay had acquired were, until the year 1876, kept at his residence at Elizabeth Bay; as by this time they had in the aggregate begun to assume considerable proportions, and to be a tax upon the

resources available for their safe keeping, he in the year mentioned had two buildings put up for their better accommodation in the garden upon part of which the Linnean Hall now stands. The larger of these was set apart for the reception of all but the entomological specimens; the latter were accommodated in the smaller building, which also provided a work-room for Sir William, who for a number of years regularly devoted his mornings, and usually also portion of the afternoons, to biological work, and also a room for the taxidermist and articulator, who for some time was attached to the Museum in addition to the Curator, Mr. Masters, who from its commencement has had charge of it.

During Sir William Macleay's life-time, his Museum was always accessible to naturalists engaged in research and desirous of referring to its treasures; and visiting biologists from other countries were sure of a hearty welcome from him and of such aid as he could afford, as the late Miklouho-Maclay and Mr. W. H. Caldwell have testified. On his arrival in Sydney in 1878, Miklouho-Maclay lost no opportunity of enthusiastically advocating the establishment of a Zoological Station in Sydney, and as one result of his efforts a committee was appointed by the Linnean Society of New South Wales to consider certain recommendations set forth by him in a paper communicated to the Society in August of that year. The committee, after due consideration, brought up a favourable report, which embodied the following offer from William Macleay :—

"I think it so desirable that Baron Maclay's proposal should be carried out quickly, and that we should be able to announce at once to the scientific world that a Zoological Station is actually in existence in Sydney, that I offer to guarantee, until final arrangements are concluded, to find ample room, either in or near my Museum, for any visitors to this country who wish to undertake the study and investigation of any branch of Natural Science. And I further guarantee that such students shall have free access to, and the use of, my Museum, library, and microscopes. This engagement on my part is limited, of course, to the *bona fide* student, and does not apply to the mere collector, whether amateur or professional."*

Of Sir William Macleay's intentions respecting the ultimate disposal of his collections in the form of an announced testamentary bequest to the University of Sydney, the authorities thereof had had an informal notification as far back as 1876. Subsequently he decided to make the presentation during his life-time and to provide the sum of £6000 endowment for the curator's salary, on condition that a suitable building were forthwith erected to receive the collections. At the solicitation of the Senate of the University, the Government authorised the erection of a plain but substantial building in close proximity to the main University buildings; and shortly after its completion, in the latter part of 1889 and the beginning of 1890 the collections were removed from the temporary buildings at Elizabeth Bay, in which for some thirteen years they had been housed, to the new quarters at the University.

* Proceedings of the Linnean Society of New South Wales, Vol. iii. p. 162.

The only conditions attached by Sir William Macleay to his donation were—that the present curator should be continued in office; that the endowment of £6000 for the salary of a curator should be used for this and no other purpose; and that the Museum should be made easily accessible to students of natural history and members of the Linnean Society of New South Wales.

The Macleay Museum building contains a single spacious hall, 200 feet long by 76 feet wide, provided with a gallery 13 feet wide at the sides and 26 feet at the ends, the space below the gallery being divided by partitions into a series of bays, eleven on each side, each bay having a large window.

The Macleay Collection is, as might be expected, richest in representatives of the Australian fauna, almost every department of which, except, perhaps, in the case of some of the soft invertebrates difficult to preserve satisfactorily, is, at least, fairly, and in many cases well, represented. The especial feature of the Museum is, of course, the entomological department, not only by reason of the historic interest attaching to it as representing the accumulation of more than a century's collecting by Macleays of three generations, but as comprising the finest collection of Australian insects extant; and it must ever be a source of gratification to Australian entomologists that so remarkable a collection has not only been preserved intact, but that, held in trust by the University of Sydney for the nation, it will continue to be available for study to present and future generations of workers. The following additional particulars will be of interest:—

The anthropological and ethnological collections include over 200 crania of aboriginal Australians and natives of New Guinea and the South Sea Islands, six entire skeletons of natives of Torres Straits, and many hundreds of specimens of native weapons, implements, and utensils from Australia, New Guinea, Melanesia, etc.

The collection of Mammalia comprises nearly 500 specimens (including skins, skeletons, and skulls) of Marsupials and Monotremes, and nearly 400 specimens of other orders. The collection of Birds is a particularly valuable one, comprising no fewer than about 10,000 specimens—a fair number of representatives of the Australian species mounted, the rest unmounted. There are upwards of 6000 specimens of Reptiles of all orders, mostly in spirits. The Batrachia, too, have not been overlooked. The collection of Fishes is very extensive; on a rough estimate there are about 13,000 specimens of all kinds, mounted and in spirits.

Of the Invertebrata the Insecta are the most largely represented, and it would be quite impossible to arrive at even an approximate estimate of the immense multitudes of representatives of all orders that fill the drawers of the insect cabinets.

There is also a fine collection of Crustacea comprising 7000 or 8000 specimens, and a good series of Australian Spiders.

The Mollusca, though not nearly so numerous as the Insects, are yet a very numerous collection, which Mr. Masters estimates at not less than 50,000.

Of the numbers of the other Invertebrata, no estimate has been formed; but there are many thousands of specimens of Worms, Echinoderms, Coelenterates and Sponges.

Besides these zoological specimens, there is also a considerable, though much less important, collection of geological specimens from various sources.

In his Presidential Address to the Linnean Society of New South Wales in 1892, Professor Haswell in reviewing Sir William Macleay's well-directed plans to promote the welfare of science pertinently pointed out that—

"There are several ways in which an individual possessed of the necessary means and the necessary enlightenment may further the ends of science. He may himself add by his own investigations to the sum total of our knowledge. He may, without himself prosecuting any researches, accumulate in an intelligent way material with the aid of which others may be enabled to advance the science in which he is interested. He may by his personal influence and example be the means of inducing others to devote their energies to scientific work. He may provide facilities, as, for example, by building laboratories or biological stations, furnishing instruments and apparatus, and forming collections of scientific books, by which scientific workers may carry on their work with convenience and thoroughness. Or he may provide funds by means of which investigators may be enabled to devote all their time and energy to the work of research.

"Now I think I may say that Sir William Macleay contributed to the progress of science to a greater or less extent, not in one or two only, but in all of these ways."

The indebtedness of the Colony of New South Wales to Sir William Macleay is not alone confined to the services rendered by him of which mention has already been made. He was at all times ready to place his scientific knowledge and experience at the service of the country, and in this capacity rendered important and valuable aid as Chairman of the Royal Commission on Oyster Culture in 1877, as Chairman also of the Royal Commission appointed in 1880 to inquire into and report upon the actual state and prospect of the Fisheries of the Colony, as Chairman of the first Fisheries Commission appointed under the Fisheries Act, as a Member of the Board of Trustees of the Australian Museum and also of the Public Library, and from 1875 as Fellow of the Senate of the University of Sydney. Sir William Macleay also for a time was Captain in the Volunteer Artillery.

The honour of Knight Bachelor was conferred upon Sir William Macleay in 1889. His death took place on December 7th, 1891, in his seventy-second year.

It is, happily, no new thing for public-spirited men in Australia, as elsewhere, of their wealth to provide for the needs, in the way of endowment, of educational or other institutions or enterprises whose aim it is to advance knowledge, to ameliorate human want or suffering, or by the discoveries of exploring parties to make known the resources of the most out of the way portions of the continent ; nor have such been exclusively confined to any one colony. But among Australian public benefactors whose names are deservedly held in honour and esteem, William Macleay occupies a niche entirely his own. He was pre-eminently the Patron of Natural Science in Australia ; and as such he was a worker as well as a giver. And splendid though his benefactions were, amounting from first to last to about one hundred thousand pounds, he has left his adopted country a nobler and more estimable heritage in his example and in his long-continued personal service without fee or expectation of reward, and without any craving for outward and visible signs of public approval or popularity, actuated simply by a sincere desire to see the land of his adoption, whose splendid possibilities he fully recognised, attain the full measure of its intellectual as well as of its material development.

J. J. Fletcher.

CONTRIBUTIONS TO OUR KNOWLEDGE OF CERATODUS.

PART I.—THE BLOOD VESSELS.

BY W. BALDWIN SPENCER, M.A., PROFESSOR OF BIOLOGY IN THE UNIVERSITY OF MELBOURNE.

(Plates I.-V.)

CONTENTS.

I.—INTRODUCTORY.

In September of 1891 the opportunity presented itself of spending a short time in Queensland. I was in hopes of securing embryos of Ceratodus, but owing to the lateness of the season and University work which necessitated my return to Melbourne, I was unable to do this. I am much indebted for valuable assistance to the Hon. A. Norton, President of the Royal Society of Queensland, to the Secretary of the latter, Mr. W. Ryott Maughan, and to Mr. Thomas Illidge of Gayndah.

As is well known, Ceratodus is now confined to two rivers in Queensland—the Mary and the Burnett. My time was spent in the neighbourhood of Gayndah, a township on the latter. It was in this district that the first embryos of Ceratodus were discovered by Mr. Caldwell.

The Burnett is a river of considerable size, with alternating deep pools and shallow runs. Ceratodus is fairly plentiful, but you may fish for a considerable time without catching one, probably because its normal food is vegetable matter such as river weeds and gum-tree fruit. To obtain it you must search in the deep, quiet pools which are full of water in both summer and winter. It is very doubtful indeed if Ceratodus ever lives in a normal condition out of water; it certainly does not appear to ever bury itself in mud when the waters dry up.

The lung is used, not as at times the only, but as always an accessory organ of respiration. Without doubt there are, however, times when this organ is of especial use to it.

The year in the Burnett district may be divided into three periods—(1) the rainy season, (2) the intermediate season, when the river is flowing freely but is not flooded and (3) the dry season, when the river is low, but when the deep pools retain a good supply of water and are normally connected by a trickling stream. Ceratodus lives in the deep pools which rarely, if ever, become completely dried up.

Surprising statements have been made very recently as to its habits. For example, Lumholtz* states that Ceratodus may be seen creeping out of the water and sunning itself upon logs. Anyone who has taken one out of the water and watched it will realise the impossibility of its doing any such thing. The fins, useful enough as paddles in the water, are quite incapable (as Dr. Günther pointed out) of sustaining its weight; in fact on land it is utterly helpless and unable to move. I fancy that

* "Among Cannibals."

Lumholtz's informant must have mistaken a large water-lizard (*Physignathus lesueurii*) which is frequently met with in the Burnett for a Ceratodus. The former animal constantly climbs out on to logs and suns itself and may grow to a large enough size to be mistaken for a Ceratodus. It is dark-coloured like the logs and rapidly slips off into the water when disturbed. Dr. Günther refers to statements as to the animal going on to land, or at least mud-flats, but regards these as doubtfully true. In discrediting them he was, I believe, after watching the animal in its native haunts, perfectly correct and this for two reasons—first, because the animal cannot move on land; it does not when taken from the water even throw itself about in the lively way of ordinary fish and never attempts to raise itself by its weak paddles; and second, because out of the water, unless kept moist artificially, its life is limited to a comparatively short time.

The noise made by Ceratodus, and to which Dr. Günther refers, is due probably to the expiration of air from the nostrils just as the animal reaches the surface, the result being what the fishermen of the district call a "spouting."

Whatever be the state of the water, the animal appears to constantly breathe air; but there are two special times when its lung is probably of greatest use to it. The first of these is when the river is flooded by the yearly rains and the water is charged with an immense amount of fine sandy particles washed down from the surrounding country. The Burnett runs in a deep channel with every now and then great sandbanks—bare in dry weather and extending for long distances. The quantity washed down into the river during often a very few hours must be enormous. The second is when the river is abnormally low during the hot season and when its waters become fouled with gases from decomposing vegetable matter—for as the hot season advances the river weeds increase very rapidly in quantity. During either of these times it is easy to see that the possession of a lung to an animal which could remain in its normal element would be of great service.

The development of the swimming bladder of ordinary fishes into the lung of Dipnoi has been attended with certain important changes in the circulatory system and we find that the latter presents, as might have been expected, remarkable points of affinity to not only the arterial but also the venous system of Amphibia.

So far as I am aware, our knowledge of the blood-vessels of Ceratodus is as yet comparatively small. I have been unable, owing to lack of literature in Melbourne, to ascertain exactly what is already known. To my friend Professor Haswell of Sydney University I am much indebted for a copy of the part of Boas'* paper referring to Ceratodus, though, unfortunately, in the paper from which Professor

* Ueber Herz und Arterienbogen bei Ceratodus und Protopterus. Von J. E. V. Boas. Morph. Jahrbuch, VI. pp. 331-354.

Haswell was good enough to make this copy for me, the plates were missing. If I fail to acknowledge work previously done it is simply owing to inability to refer to this in Melbourne. Judging, however, from the papers by Günther,* Boas and recent text books, little has been described beyond the structure of the heart and the relation of some of the main vessels, and it appeared to be worth while to describe as fully as possible the whole circulatory system of Ceratodus at the risk of traversing ground already passed over to a certain extent by previous workers.

II.—THE ARTERIES.

A. *The ventral aorta and afferent branchial arteries.*

The ventral aorta in Ceratodus, as in other Dipnoi, is extremely short; in fact, the four afferent branchial arteries, as shown by Boas and Günther in Ceratodus and by Owen and others in Lepidosiren, arise almost directly from the anterior end of the strongly muscular conus arteriosus, their roots being close together as in the Amphibia.

When lying in their normal position (fig. 1), the first and second are nearest to the ventral surface of the body; slightly dorsad of these the third enters and covered over by the third the fourth enters. In the normal position, the third artery must be pulled aside before the root of the fourth can be seen.

The arteries pass forwards and at the same time bend outwards and slightly dorsally to enter the four branchial arches (fig. 20), each of which bears a holobranch.†

The gills have been already described and figured by Günther‡; but as there are one or two points of importance connected with the relationship of the blood vessels dependent upon the exact distribution of the branchial laminæ, the gills are here described and represented in figs. 20 and 21. With minor exceptions the following account agrees closely with that given by Günther. The anterior hemibranch is attached to the hyoidean arch, and may hence be conveniently termed the hyoidean hemibranch. This is equivalent to the opercular gill of such forms as Elasmobranchs, Holocephali, Chondrostean Ganoids, and Lepidosteus, and is spoken of by Günther as the pseudobranchia.

* Description of Ceratodus, a Genus of Ganoid Fishes, recently discovered in Rivers of Queensland, Australia. A. Günther. Phil. Trans. Roy. Soc. London, 1871, p. 511.

† In the use of this convenient term, as in that of hemibranch, I have followed Prof. T. J. Parker. A hemibranch is the whole set of gill filaments on one side of a gill arch. A holobranch is composed of the two sets, one on either side of a gill arch.

‡ *Loc. cit.* p. 539, pl. XXXVII. fig. 6.

The four first branchial arches form membranous folds. Except at their upper and lower extremities, the outer edges of the arches are concealed by the projecting tips of the branchial laminæ. The attachment of the latter, each of which is about $\frac{1}{8}$ inch in width, is shown in fig. 4. Dorsally and ventrally the laminæ of each hemibranch pass from the arch itself on to the dorsal and ventral walls respectively of the successive clefts (fig. 21). The result is that of the nine hemibranchs the two first are connected dorsally, the third and fourth, fifth and sixth, seventh and eighth both dorsally and ventrally. Thus, as shown in fig. 21, the second, third, and fourth gill clefts are completely surrounded by branchial laminæ. The ventral part of the second and the ventral and dorsal parts of the ninth hemibranch are not connected with those of other arches.

The internal surface of each arch bears a double series of small triangular plates —the gill-rakers. The series of these is complete on both the hyoidean and fifth branchial arches, though the latter bears no laminæ. The arrangement can be seen by reference to figs. 20 and 21.

Each of the four afferent arteries passes up one of the branchial arches, giving off right and left branches to the internal attached edges of the laminæ, and at the dorsal end gives off on either side a small branch, which follows the course of the corresponding hemibranch. The relative position of the afferent artery is shown in fig. 4, and will be dealt with later when dealing with the efferent arteries. There is no afferent artery carrying venous blood to the hyoidean arch such as is present in Lepidosiren.

B. *Efferent branchial arteries, epibranchial arteries, and dorsal aorta.*

As in Plagiostomes, there is an efferent branchial artery for each hemibranch—that is there are two in each branchial arch. The general arrangement of these is shown diagrammatically in figs. 2, 3, and 5.

Every branchial lamina is provided with a small efferent vessel passing along its outer free border, and each of these opens into the efferent artery of its own side (fig. 4). The artery of the hyoidean hemibranch will be dealt with shortly.

The two efferent vessels of each branchial arch run dorsally, and *the pair in each arch* unite together to form a single epibranchial artery (figs. 2 and 5). In each arch the posterior is somewhat smaller than the anterior one.

Those of the fourth and third arches end blindly on the ventral side, but, whilst the same is true of the posterior vessels in the second and first arches, the anterior ones here give off important branches.

On the dorsal surface of the gills the efferent artery of each hemibranch bifurcates, the larger of the two branches thus formed passing upwards to unite with its fellow of the same holobranch, the other following the course of the hemibranch at the base of the laminæ and uniting with that of the hemibranch immediately caudad or cephalad of it as the case may be. The relationship of the various branches will be seen by reference to figs. 2, 3, and 5.

The relation of the various efferent and afferent arteries to each other and to the other parts of the gill is seen in fig. 4, which represents semi-diagrammatically a transverse section across one of the branchial arches.

The cartilaginous arch itself lies on the œsophageal side and has its inner surface concave in outline; on either side of the central membranous fold which forms the arch external to the cartilage lies a branchial lamina. In the middle line and immediately external to the cartilage lies the single afferent vessel which is of considerable size; from this a small branch arises on either side, running along the inner attached end of a lamina. It breaks up into a plexus of small vessels which pass outwards towards the free border of the lamina and there communicate with an efferent vessel which runs towards the base of the lamina and opens into the efferent vessel of its own side. The afferent branches on each side are united across the median membranous fold of the arch by small cross-vessels.

The two efferent vessels run one on either side of the cartilaginous arch and between the anterior efferent and the afferent artery lies a single nerve. There do not appear to be two present, as there are in such forms as Mustelus.

Though (as described already by Boas) two efferent vessels are present in each arch, it may be noted that these differ markedly from those of Mustelus and other Plagiostomes in that the pair in each arch unite together to form an epibranchial artery; whereas in the latter the posterior efferent vessel of one arch unites with the anterior of the one lying posteriorly to it. In this respect Ceratodus retains in the adult what is an embryonic feature, according to Dohrn (as quoted by Parker), in Pristiurus, where, prior to the connection between the efferent branches of adjacent arteries, the pair of each one falls into the dorsal portion leading to the dorsal aorta.

In the development of the amphibian branchial blood vessels there is present, as described recently by Marshall and Bles* in Rana, an afferent and single efferent vessel; there appears to be no trace of a second efferent and as the one present lies to the anterior side of the afferent, it must be regarded as the homologue of the anterior of the two present in Plagiostomes and Ceratodus, in both of which again it

* Studies from the Biological Laboratories of the Owens College (1890). The Development of the Blood Vessels in the Frog. Marshall and Bles. p. 186.

is interesting to note that it is the larger of the two. In this respect the embryo Rana presents a feature characteristic of the adult Holocephali and Teleostei and of the embryo Pristiurus.

The four epibranchial arteries formed by the union of the successive pairs of efferent vessels pass backwards and towards the middle line immediately beneath the vertebral column, and by their union give rise to the dorsal aorta. The epibranchial arteries unite in pairs—first, those of the first and second branchial arches, then those of the third and fourth (figs. 2, 3, &c.). By this union on each side two main arteries are formed which again unite to form the dorsal aorta which runs backwards immediately beneath the vertebral column until at the posterior end of the body where the hæmal arches commence it is continued into the tail region as the caudal artery.

C. *Branches arising from the efferent branchial arteries and the epibranchial arteries.*

(a) From the anterior efferent artery of the first branchial arch (figs. 2, 3, and 6).

Instead of ending blindly at the ventral termination of the first branchial hemibranch, the efferent vessel is continued downwards towards the ventral surface. It turns forwards and at the level of the posterior edge of the hyoid arch comes to lie close to the inferior jugular vein. At this point it divides into two. The first of these runs forwards into the muscles on the lower surface of the head and passes to the region in the floor of the mouth, where it gives a small branch which unites in the median line with one from the corresponding vessel of the opposite side. This vessel may be called the *lingual artery* and in its origin from the ventral end of the efferent vessel of the first branchial arch it is precisely similar to that of the lingual artery as described by Marshall and Bles in the frog (figs. 2, 3, and 6, *ling. art.*).

The second branch turns outwards and passes immediately dorsad of the inferior jugular vein, crossing to the posterior side of this (fig. 6). It then runs along the outer flattened surface of the ceratohyal beneath the opercular bone, giving off a few small branches to the muscles in this part. Then passing through a notch immediately beneath the 7th cranial nerve it turns sharply backwards and runs to the hyoidean hemibranch. In this it divides into two branches, one running downwards and the other upwards to join the small branch running across to the anterior efferent artery of the first branchial arch.

This second vessel is the *hyoidean artery* (figs. 3 and 6, *hy. art.*).

Thus, as in Teleostei, the hyoidean gill is supplied with arterial blood from the ventral end of the first branchial efferent artery. In Protopterus and Lepidosiren,

on the other hand, the hyoidean vessel arises from the first afferent artery, and thus carries venous blood.

(b) From the anterior efferent artery of the second branchial arch (figs. 2, 3, and 6).

This vessel, like that of the first arch, does not end blindly. It is continued ventrad of the gill arch and forms a vessel which may be called the *hypobranchial artery*.

This runs first of all towards the ventral surface and then turns backwards in front and ventrad of the second afferent vessel. It then divides into two branches, of which the first immediately turns dorsalwards and at the same time towards the median line. Passing dorsad of the 3rd and 4th afferent vessels and of the heart, it is distributed to the ventral wall of the œsophagus and forms the *œsophageal artery* (figs. 2, 3, and 6, *œs. art.*).

The second branch first gives off a vessel running ventrally and supplying the muscles ventrad of the afferent vessels and then bifurcates. One of the resultant vessels passes to the anterior wall of the pericardium (fig. 6, *peri. art.*), the other runs to the ventral side of the conus arteriosus, and then penetrating the muscle wall of the latter can be traced as far as its union with the ventricle. This forms the *coronary artery* and I have been unable to detect any corresponding branch from the hypobranchial artery of the left side (figs. 2, 3, and 6, *cor. art.*).

With the two exceptions above described the efferent vessels of the branchial arches end blindly on the ventral surface, those of consecutive arches not being definitely united together as they are in such an Elasmobranch as Mustelus.* In this respect again the Dipnoi agree with Teleostei and Amphibia. As stated above, in the development of Rana the efferent artery of the first branchial arch becomes directly continuous ventrally with the lingual artery, though probably both in the case of Amphibia and of Ceratodus this is not a primitive feature, but one due to modification of the blood vessels following on suppression of the gills in front of the branchial arches.

(c) Anterior carotid artery (figs. 2 and 5).

The artery which from its distribution appears to be the equivalent of the vessel of this name in fishes is in direct connection with the hyoidean hemibranch. The small vessels in the laminæ of the latter open into a collecting vessel (= post-efferent vessel of other arches ?), and from about the middle of the length of this, at the level where the hyoidean artery enters, the anterior carotid arises. Its origin is

* *Cf.* Parker, Phil. Trans. R. S. 1886, pl. XXXIV. and XXXV. figs. 1 and 6.

represented diagrammatically in figs. 2 and 5. It runs for a short distance just outside the cartilage at the posterior end of the skull, but soon penetrates this, passing dorsad of the superior jugular vein and hyoidean branch of the 7th cranial nerve; it pursues an almost straight course, trending slightly forwards and towards the median line. Passing ventrad of the posterior carotid and of the branch between the 7th and 9th cranial nerves and of the main branch of the 5th nerve, it reaches the brain cavity, across the floor of which, behind the level of the infundibulum, it sends a branch which unites with one from the corresponding artery of the other side. There is thus formed a small *circulus cephalicus* (fig. 5 *c.c.*), though this is apparently stated to be absent in Dipnoi.*

The main branch enters the brain case and divides into (a) an anterior cerebral branch which supplies the front part of the brain, and (b) a posterior cerebral branch which supplies the hind part of the brain (fig. 5, *ant. cer. art.*, *post. cer. art.*)

(d) Posterior carotid artery (figs. 2 and 5).

This is a larger branch than the anterior carotid. It arises on each side from the epibranchial artery of the first branchial arch, and immediately runs forwards into the cartilaginous cranium. It passes to the outer side of the auditory organ and then bends inwards towards the middle line until it crosses the anterior carotid, immediately ventrad of which it lies. The fifth nerve lies dorsad of both and gives off a branch which passes round the posterior side of both arteries where they cross one another and then turns immediately forwards ventrad of them and runs to the anterior end of the head.

Shortly after entering the cartilage the artery gives off a branch which passes downwards and then runs forwards under the parasphenoid to the roof of the mouth. This is the *palatine artery* (fig. 5, *pal. art.*).

Just after crossing the anterior carotid it divides into two branches, of which one runs outwards to the orbit, forming the *orbital artery (orb. art.)*, and another runs on till it comes to the optic nerve, on which it branches.

Of the above arteries the anterior carotid must be regarded as equivalent to the combined pseudobranchial and anterior carotid arteries of such forms as Mustelus and Raja,† where a pseudobranch is present, and to the anterior carotid of Callorhynchus,‡ where, as in Ceratodus, no pseudobranch is present. In all the forms, though the

* *Cf.* Forms of Animal Life, 2nd Edit. Jackson, p. 425.
† *Cf.* Parker, *loc. cit.* p. 693, fig. 1.
‡ *Cf.* Parker, *loc. cit.* p. 693, fig. 17.

exact point of origin and relationship to other vessels varies somewhat, still the artery in question agrees in taking its origin from the efferent artery of the hyoidean hemibranch. Here again modifications have been produced by suppression of anterior gills and consequent changes in the arrangement of blood vessels connected with these.

In the case of the posterior carotid* the point of origin varies somewhat from that which obtains in such forms as Mustelus and Callorhynchus. The differences may be regarded as due to the fact that the efferent artery of the hyoidean hemibranch is not connected directly, as it is in the latter forms, with an epibranchial artery. In Callorhynchus, at all events it arises from such a connecting vessel, whilst in Ceratodus it does not, and we may probably regard the posterior carotid as equivalent to the latter artery proper together with the proximal portion of a suppressed epibranchial artery belonging formerly to the hyoidean arch. The correctness or otherwise of this can only be determined by a study of the development of the vessels. In its origin the posterior carotid of Ceratodus corresponds closely to the internal carotid of Rana, though, at the same time, the distribution of the latter is rather that of the vessel above described as anterior carotid. As Parker points out,† the use of the name "carotid" in regard to the vessels of fishes, &c., "must be taken to imply nothing more than a general correspondence with the similarly named vessels in the higher vertebrata."

(e) From the united first and second epibranchial arteries (figs. 2 and 5).

Immediately behind the point of union of the first and second epibranchial arteries there arises a comparatively small vessel which runs directly upwards behind the skull and in front of the first modified rib. From its position it may be called the *occipital artery* (figs. 5 and 14, *occ. art.*). At about the level of the spinal cord it divides into two branches. The first of these continues the course of the main vessel and runs directly upwards to supply the muscles of the mid dorsal surface immediately behind the skull. The second turns backwards and gives off three branches, (a) one running to the side of the vertebral column—the *anterior vertebral artery*, (b) one running towards the surface through the muscles in the body wall behind the shoulder girdle; in all probability this runs to the level of the lateral cutaneous vein, to be described later and accompanies this in its course and (c) one which runs downwards and round the anterior margin of the first rib—the *costal artery*.

* *Cf.* Parker. *loc. cit.* p. 695, figs. 1 and 7.
† *Loc. cit.* p. 693.

D. *Vessels arising from the dorsal aorta.*

These vary on the two sides of the body.

(*a*) *The left side.*

(a) Subclavian (fig. 2).

This name was originally applied by Dr. Günther* to the artery in question, and it was rightly pointed out by him that the left subclavian was twice as large as the right. The vessel arises at the level of the fifth muscle segment behind the scapula.

Immediately after its origin it divides into two branches :—

(1) The *brachial artery* (figs. 2 and 14, *l. br. art.*). This runs outwards, downwards, and slightly forwards to the attachment of the pectoral limb. It gives off first a branch to the muscles behind the lower part of the coracoid and, as it enters the limb, another small branch which runs round to the anterior face of the lower part of the coracoid *(corac. art.)*.

(2) The *anterior spermatic (or oviducal) artery* (figs. 2 and 14, *l. ant. sperm. art.*). This is a large branch—larger than the brachial—which passes backwards almost immediately from the point of origin of the subclavian. It runs nearly parallel to the vertebral column, crosses the large spermatic vein of the same side, and enters dorsally the anterior extremity of the body cavity. Here it passes at once into the spermatic band (or the ovary). It gives off branches to this, and at the posterior end *is directly continuous with the posterior spermatic (or oviducal) artery.* There is no difficulty in tracing this artery along the whole length of the spermatic band, though its size is somewhat diminished some distance from the anterior end and increases again towards the posterior end.

(b) Segmental arteries.

These, as in other forms, are given off in each segment, right and left, from the whole length of the dorsal aorta, and supply the dorsal muscles.

(c) Iliac, renal, posterior spermatic (or oviducal), intestinal, and cloacal arteries (figs. 10 and 14).

From a point somewhat behind the level of the anterior end of the kidneys arises a large vessel which divides into the following branches :—

* Phil. Trans. R.S. London, 1871, p. 511.

(1) *Iliac artery.*—This is a comparatively small vessel running downwards, outwards and backwards to supply the hind limb (figs. 10 and 14, *l. iliac art.*).

(2) *Posterior spermatic (or oviducal) artery.*—This runs at first downwards and then turns forwards, passing through the anterior part of the kidney to supply the testis (or ovary) along which it runs, and, as stated above, is directly continuous with the anterior spermatic (or oviducal) artery (figs. 10 and 14, *l. post. sperm. art.*).

(3) *Renal artery.*—This runs downwards and backwards to enter the left kidney, where it divides into an anterior and posterior vessel (figs. 10 and 14, *l. renal art.*).

(4) *Posterior intestinal and cloacal artery.*—This forms a branch which runs downwards towards the median line between the right and left kidneys. It divides into two branches. One of these runs anteriorly and slightly dorsally till it touches and becomes attached to the ventral wall of the lung. From this point branches are given off to the dorsal wall of the intestine (figs. 6 and 12, *post. int. art.*). The other runs backwards between the two kidneys and breaks up into branches, which supply the parts in the cloacal region (figs. 10 and 14, *clo. art.*).

(β) *The right side.*

(a) Cœliaco-mesenteric artery.

As pointed out by Günther, this arises from the aorta on the right side immediately in front of the subclavian (= brachial artery of this side). In Elasmobranchs (as Mustelus) it arises comparatively close to the entrance of the last epibranchial artery into the dorsal aorta and in Amphibia the corresponding vessel arises from close to the union of the systemic arches or even from one of the latter. In Ceratodus a considerable interval separates it from the commencement of the dorsal aorta.

Owing to the extreme shortness of the alimentary canal in Ceratodus—a point of strong contrast between the latter and either Elasmobranchs or Amphibia (except certain Urodeles, such as Proteus), and of resemblance between the Dipnoi and Holocephali—together with the absence of any clearly marked stomach and owing also to the fact that it gives off the anterior spermatic (or oviducal) artery of its side, this vessel has somewhat different relationship from that which obtains in the case of the artery of the same name in Elasmobranchs.

In Ceratodus it forms a large vessel which runs at first outwards but soon turns downwards and then backwards and runs ventrad of the brachial artery to enter the body cavity where the liver is attached to its walls anteriorly. Piercing the liver it gives rise to three main branches (fig. 14) :—

(1) The *hepatic artery* giving off branches to the lobes of the liver *(hep. art.)*

(2) The *enteric artery*, which forms the largest of the three branches and supplies the alimentary canal *(ent. art.)*. This appears to be equivalent to the anterior mesenteric vein as described by Parker in Mustelus, the cœliac branch of the latter being probably represented in Ceratodus merely by the hepatic artery.

(3) The *right anterior spermatic (or oviducal) artery.*—This runs backwards through the right testis or ovary as the case may be. It differs from the corresponding artery of the left side in that it is not directly continuous with the posterior spermatic (or oviducal) artery, though small branches pass directly from one to the other *(r. ant. sp. art.)*.

The enteric artery as above said supplies the alimentary canal. Passing to the ventral side of this, it turns backwards slightly to the right of the median line and then pierces the outer muscular coat just anterior to the point at which the spiral fold commences. This part forms the widest portion of the canal. Where the spiral fold commences the artery breaks up into three branches :—

(1) The *dorsal intestinal:* this follows the curve of the fold until it reaches the mid dorsal line and then runs backwards along this to the posterior end (figs. 9, 12, and 13, *d. int. art.*)

(2) The *ventral intestinal:* this passes to the mid ventral line and runs along this to the posterior end (figs. 9, 12, and 13, *v. int. art.*).

(3) The *intra-intestinal:* as described by Parker in Scymnus and Mustelus this forms a vessel which runs along the free edge of the spiral fold, this free edge in Ceratodus being very much thickened. As noted by Günther the spiral fold contains a remarkable organ of very doubtful nature which is filled with a slimy, dark sepia-brown substance. The presence of this renders it very difficult to dissect out the artery ; but the relative positions of the three vessels can be seen from the diagrammatic section drawn in fig. 12.

The larger first portion of the intestine has its walls supplied by two special branches (fig. 9), of which one arises from the dorsal intestinal and the other from the ventral intestinal artery.

Along their courses the dorsal and ventral arteries give off lateral branches corresponding in position to the points at which they cross the spiral fold. As this made some nine turns in the course of the intestine of the specimen figured (fig. 9), there are on each side nine branches, and those arising from the dorsal and ventral vessels may run into one another round the sides of the intestine. Each one also gives off branches both forwards and backwards and down into the spiral fold.

After carefully cutting the intestine open along one side and removing the spiral fold along its whole length from the intestine walls, the blood vessels and their courses in the latter may be clearly seen when the wall thus opened out is held up against the light.

(b) Right brachial artery.

This arises immediately behind the cœliaco-mesenteric artery and corresponds in ts branches and distribution to the artery of the left side (fig. 14, *r. br. art.*).

(c) Iliac, renal, and posterior spermatic (or oviducal) arteries.

The common trunk giving rise to these arises from the aorta at a point somewhat posterior to that from which the corresponding vessel is given off on the left side.

(1) *Right iliac artery.*—As on the left side, its point of origin lies close to the aorta. It runs outwards, downwards, and backwards to the hind limb of its own side (figs. 10 and 14, *r. il. art.*)

(2) *Right renal artery.*—This runs backwards and supplies the right kidney (figs. 10 and 14).

(3) *Right posterior spermatic (or oviducal) artery.*—This turns forwards and runs through the posterior part of the testis (or ovary), to which it gives off branches. Unlike that of the left side, it is not directly continuous with the anterior spermatic (or oviducal) of its own side, but the two communicate by small branches (figs. 10 and 14, *r. post. sp. art.*).

III.—THE PULMONARY SYSTEM.

Though this, like the arterial arches, has been described by Boas, it will be convenient, in order to render this account as complete as possible, to describe it here in full.

Dr. Günther's original description showed the nature of the lung so far as macroscopic appearances are concerned, and the positions occupied by the vessels on the lung.*

* Phil. Trans. R.S. London, 1871, p. 540.

A.—*The lung* (figs. 17 and 18).

The lung, as described by Dr. Günther, arises from the ventral side of the œsophagus to the right of the median line. It then passes up the right side being closely apposed to the œsophageal wall and for the rest of its course lies on the dorsal surface of the alimentary canal beneath the vertebral column being only separated from this by the dorsal aorta the ventral face of which is firmly fused with the median dorsal line of the lung. Save for a median ventral and dorsal stripe the whole external surface shows small rounded protuberances corresponding to the "air-cells" within. The whole surface again, save in these two parts, is marked by a reticulation of small blood vessels which pass off from the five main ones to be shortly described. By the broad dorsal stripe it is firmly attached, as above said, to the ventral wall of the aorta and also to the peritoneal membrane lining the body cavity immediately on either side of this. A strong median mesentery connects, for the greater part of its length, the mid ventral wall of the lung to the mid dorsal wall of the intestine. A mid ventral mesentery, again, passes from the ventral intestinal to the ventral body wall, though this is not continuous but broken up into a median part lying half way along the intestine after which comes a short gap followed by a more posterior portion after which again is a further gap across which pass thin strong slips of mesentery (fig. 19, *mes.*). The extent of the development of the ventral mesentery appears to vary somewhat in different examples.

The internal structure of the lung is beautifully shown in Dr. Günther's memoir.* To quote his description :—"The septa separating the compartments are imperforate membranes, so that each compartment can be separately filled with fluid, only the side towards the median line of the lung being open. The bottom of the compartments is again divided into a number of larger and smaller cells by reticulated septa, which are very irregularly disposed." According to this author, the compartments are arranged almost symmetrically : in the four specimens of Ceratodus whose lungs I cut open this only obtained in the anterior third ; backward from this the septa begin gradually to change their relative position until about half way down and for the remainder of its length each septum lies opposite to the centre of a compartment on the other side of the lung.

B.—*The pulmonary arteries* (figs. 17 and 18).

The fourth epibranchial artery, as described by Boas, gives off on each side a large vessel prior to its junction with the third, and the course of the pulmonary vessels thus formed varies on each side.

* Pl. XXXVIII. fig. 2.

(a) Right pulmonary artery (figs. 17 and 18, *r. pul. art.*).

From its point of origin this passes backwards and slightly inwards till it comes to lie close to the right side of the vertebral column. It passes beneath the cœliac and subclavian arteries, and entering the body cavity passes directly to the dorsal surface of the right half of the lung, along the length of which it runs in close contact with the dorsal aorta. It therefore only gives off branches on the right side. On the left side there is no artery in a corresponding position. Its course and branches can easily be determined by injecting from the pulmonary artery on the right side close to the epibranchial vessel. A little way beyond the latter it passes through stiff fasciæ in which its course is difficult to make out unless the vessel has been previously injected.

(b) Left pulmonary artery (figs. 17 and 18, *l. pul. art.*).

The course of this is very different from the simple straightforward one of the right artery. From the fourth epibranchial vessel of the left side it passes backwards until it reaches the level of the subclavian artery : at this point it lies close to the left side of the œsophagus. It now bends suddenly forwards and at the same time downwards towards the ventral side of the œsophagus, then it once more turns backwards and crosses under the œsophagus just in front of the opening of the lung until it reaches the right side. Here it runs backwards close by the pulmonary vein and where the lung comes to be dorsad of the alimentary canal divides into two branches, one running down either side of the mid ventral stripe and giving off branches to the half lung of its own side. Till it comes in contact with the alimentary canal its walls are fairly but not noticeably thick. From the level of the glottis to the dorsal surface where it passes on to the ventral aspect of the lung—that is in the region where it is firmly attached to the alimentary canal—its walls are extremely thick and strong and the same is true of the pulmonary vein.

The two modifications, (a) the curious loop-like course and (b) the strong walls just described, are probably both to be regarded as adaptations to prevent any interference with the flow of blood when the animal is feeding.

Judging by the contents of their intestine which is always crammed full of vegetable matter—grass, waterweeds, gum-tree fruit, &c.—the animals must be somewhat voracious feeders. The food passing down the œsophagus distends the latter, around which, loosely attached to its walls, the artery passes : the loop in this position allows of its distension. When the œsophagus passes through the stout

" diaphragm " between the pericardium and the body cavity behind, distension of the canal would simply mean the obliteration of the lumen of the blood vessels, unless these were protected as they both are by stout walls.

In this same part also the walls of the lung are very thick and muscular.

C.—*Pulmonary vein* (figs. 17 and 18, *pul. v.*).

On the ventral aspect of each half of the lung there can be clearly seen a large vessel running parallel to and at some distance laterally from the branch of the right artery of its own side. Traced forwards, these two veins, which are richly supplied on both sides with branches, converge towards the median ventral line until slightly in front of the point of divergence of the two arteries they unite to form a single thick-walled pulmonary vein. The right branch passes under the corresponding artery before joining its fellow so that the vein lies to the left side of the main right artery. The two pass close together round the œsophagus (figs. 16 and 18) and then the vein runs forwards and towards the left side dorsad of the inferior vena cava (to be described below) and the sinus venosus to enter the auricular chamber on the left side.

A curious communication by means of a well-marked transverse vessel on each side may here be noted, which exists between the two branches of the right artery and of the vein (fig. 18, *z.*).

IV.—THE VEINS.

These have been very briefly noted by Dr. Günther whose short account refers almost entirely to the vena cava posterior and its main branches including the renal portal system.

The study of the veins is more difficult than that of the arteries but the venous system shows, as might be expected, affinities to both that of a fish on the one hand and that of an amphibian on the other. It may be said that in its anterior portion Ceratodus is typically piscine, whilst in its posterior, or trunk and caudal regions it presents a mixture of piscine and higher types such as is probably not found outside the group Dipnoi.

The veins may be conveniently grouped as follows :—

A. *Caudal vein.*

B. *Renal portal system.*

C. *Anterior abdominal system.*

D. *Hepatic portal system and hepatic veins.*

E. *Derivatives of the anterior cardinal system.*

F. *Derivatives of the posterior cardinal system, including the inferior vena cava.*

G. *Brachial veins.*

H. *Cutaneous veins.*

We will deal with these in the order indicated.

A. *Caudal vein* (figs. 10 and 16).

This runs below the dorsal aorta from the posterior end forwards to the level of the first hæmal arch. Here it passes downwards into the body cavity. As it passes forwards and downwards, it reaches a point at the level of about one-third of the length from the anterior end of the kidney (fig. 10, *x.*). It then divides into two parts, one running to the right and the other to the left, of which the right hand branch is much larger than the left.

Into each enters (a) a branch from the posterior two-thirds of the kidney and (b) a branch from the anterior third of the kidney which two branches may be regarded as *venæ renales advehentes* (fig. 10, *v.r.a.*). The main vein passes on into the testis or ovary, as the case may be, of each side, the right branch being again much larger than the left.

B. *Renal portal system* (figs. 10, 16, and 19).

The kidneys are supplied with three series of *venæ renales advehentes* in addition to those just described.

(1) *Posterior trunk veins* (=*posterior venæ renales advehentes* of Günther).

On either side of the body the venous blood from the muscle segments behind the cloacal region is collected into two veins. One of these lies more superficially than the other and passes backwards along the ventro-lateral surface of the body; the other comes from the deeper lying and more laterally placed muscles.

The two of each side unite together, just behind the cloacal region, to form a single vein which runs forward to the outer and ventral edge of the kidney on each side; into the kidney each gives off branches from its inner surface and anteriorly each enters into connection with the true renal portal vein.

Just anterior to the level of the anus a transverse vessel passes across above the ureters and intestine and unites the two posterior trunk veins. This is a well-marked transverse vessel and by injecting from the vein along the kidney of either side the kidney of the other side can be easily injected. Between this anastomotic vessel and the kidney on either side, the posterior trunk vein receives two branches (a) one from the terminal intestine walls and (b) one from the terminal parts of the ureter (fig. 19).

(2) *Intercostal veins.*

These, to the number of seven or eight, arch across to the kidney of each side from the body wall, traversing the remarkable development of cellular tissue which lies between the kidney and alimentary canal and the body wall in this part as noted by Dr. Günther. The arrangement of these intercostal veins in one particular specimen of Ceratodus is shown in fig. 19, where the lobulated external surface of the kidney is shown the organ having been pressed over towards the median line. This shows the exact relationship of the vessels as present in the particular specimen.

(3) *Renal portal vein* (figs. 7, 16, and 19).

This name is given to the vein to be now described since it corresponds in origin closely to the renal portal vein of Amphibia. It is the one described by Günther as the specially strong posterior intercostal vein of each side.

In fig. 17 it is represented as a large vessel passing across, as do the intercostals, from the body wall to the outer edge of the kidney where it joins the longitudinal vein passing forwards from the posterior trunk vein.

By injecting this vein at the point where it enters the kidney its relationship can be made out. Tracing it by this means away from the kidney it is found to penetrate the body wall slightly dorsad of and at the level of the attachment of the hind limb. It runs downwards in the muscles and is, just before reaching the angle of the pelvic plate with which the hind limb articulates, joined by a vessel passing directly forwards. It then enters the hind limb.

This may be called the *iliac vein* and must be regarded from its relationships as the equivalent of the vessel returning blood from the hind limb to the united posterior part of the posterior cardinal vein during the early developmental stages of Amphibia and subsequently to the kidney.

The renal portal system is thus of considerable extent, and the system will be again referred to after the remainder of the venous system has been described.

C. *Anterior abdominal system* (figs. 7 and 16).

Ceratodus possesses veins which may in all probability be rightly regarded as forming an anterior abdominal system comparable to that obtaining in Amphibia; though, at the same time, there exist considerable differences between the two.

Commencing now with the iliac vein, we find that, shortly after leaving the hind limb and after it has passed round to the inner side of the pelvic plate, it divides into two branches; one of these forms the renal portal vein above described, the other passes forwards across the inner face of the pelvic plate and the vein thus formed on either side of the body gradually runs towards the mid ventral line. One comes to lie on each side of the anterior process of the pelvic plate and just in front of the termination of this (fig. 7) the two are united by a small transverse vessel and almost immediately join together to form a single median vessel which runs forwards in the mid ventral line. Each of the constituent vessels may be called a *pelvic vein* (fig. 7) and each of these receives small branches from the muscles of the ventral body wall.

The single median vessel formed by their union at first lies considerably nearer to the inner than to the outer surface of the body wall; but towards the anterior end it gradually comes to lie nearer to the external surface though never so close to it as in the case of the lateral cutaneous veins. Arrived at the posterior surface of the pectoral girdle it turns to the right and passes dorsally through the diaphragm bounding the body cavity anteriorly until it passes into the pericardium and enters the sinus venosus immediately to the right of the entrance of the right hepatic vein (fig. 17). This system will also be referred to again later.

D. *Hepatic portal system* (figs. 9, 11, 12, and 16).

As in the case of the cœliaco-mesenteric artery, the veins forming this system have undergone considerable modification when compared with those, for example, of an Elasmobranch, in consequence of the relatively short alimentary tract of Ceratodus. Notwithstanding this they show a striking resemblance to vessels present in such a form as Mustelus especially in the development of an intra-intestinal vessel forming the vein of the spiral fold which is further to be regarded as a persistent relic of the primitive subintestinal trunk.

The large hepatic portal vein leaves the intestine and enters the liver by the side of the enteric artery (fig. 9, *h. p. v*).

It is formed by the union of three vessels :—

(1) The *dorsal-intestinal vein.*—For the greater part of its course this is a double vessel one lying close to either side of the dorsal-intestinal artery. At the posterior end of the intestine these vessels diverge and pass to the sides of the latter. Where the spiral fold first passes dorsally across the intestine they unite together and the single vessel thus formed runs backwards by the side of the corresponding artery following the line of attachment of the fold to the ventral surface (figs. 8, 9 and 12, *d. int. v.*).

(2) The *ventral-intestinal vein.*—This is a single vessel lying to the right side of the corresponding artery and running along the length of the intestine (*v. int. v.*).

(3) The *intra-intestinal vein.*—This passes along the thickened free edge of the spiral fold, gradually disappearing before the posterior end of the latter is reached (*int. int. v.*).

The three vessels above described, the relative positions of which are indicated diagrammatically in fig. 12, unite to form the large *hepatic portal vein* which enters and breaks up into branches in the liver.

The dorsal and ventral intestinal veins receive branches which correspond in position to the attachment of the spiral fold to the wall of the intestine as in the case of the arterial branches previously described. The arrangement of these is represented in fig. 9 and on the right side a special longitudinal vein is developed in connection with a curious glandular structure present on the wall of the intestine. Each also receives special branches from the walls of the anterior portion of the intestine.

The *hepatic veins* are two large vessels receiving the greater part of the blood from the liver. *They enter the sinus venosus* (fig. 17), *one on either side of the median inferior vena cava,* the right hepatic vein lying nearer to this than the left one.

E. *Derivatives of the anterior cardinal system.*

On either side of the body a large Ductus Cuvieri is formed by the union of the veins entering the heart, other than the hepatic and the inferior vena cava. The two pass inwards through the dorsal and posterior angles of the pericardium (fig. 17), and open into a large median sinus venosus, which may indeed be said to be formed by their union, together with the terminal portion of the inferior vena cava.

The anterior cardinal system is composed of the following veins:—

(1) *Superior jugular veins* (figs. 8, 15, and 16).

These are a pair of large vessels entering the Ductus Cuvieri, one on each side. The latter run outwards from the heart and at the same time take a forward and slightly downward course towards the wall bounding posteriorly the gill cavity. In this way each comes to lie close underneath the upper part of the coracoid of its own side. Here it receives the inferior jugular vein and a large branch which curves backward for a very short distance and is formed by the union of four other veins. The relation of these is shown in figs. 8, 15, and 16. One of the four is the large jugular vein (*sup. jug.*) which from this point runs upwards, slightly forwards and inwards, till it reaches a position above and behind the gill arches and close to the anterior border of the upper extremity of the supra-scapula. At this point it receives a number of small branches, (a) from the muscles lying immediately posterior to the supra-scapula, (b) from the muscles on the dorsal surface just behind the skull, (c) from the muscles on the dorso-lateral aspect of the head above the gill cavity and (d) from the region of the gill arches.

From this point the vein runs in a direction which lies roughly at right angles to that of its proximal part: it turns forwards almost parallel to the long axis of the body, runs horizontally above the level of the arches and pierces the cartilaginous cranium in the auditory region. Here it runs dorsad of the branches of the ninth and tenth cranial nerves as they pass outwards to the gill arches but ventrad of the connecting branch between the seventh and ninth nerves. Dipping ventralwards it passes beneath the outer part of the auditory organ and then gradually rising dorsalwards runs forward beneath the anterior and posterior carotids till it reaches the level of the apposed fifth and seventh nerves. Beyond the main stem of the fifth nerve it rises towards the dorsal surface and at the level of the orbit emerges from the cartilage and opens into a large sinus-like space beneath the temporal muscles which are covered over externally by the supra-orbital bone.

From this sinus five other sinus-like vessels diverge (fig. 15):—

(1) One towards the mid line anteriorly, into the lower layer of muscles.

(2) One almost directly dorsalwards into the upper layer of muscles immediately beneath the supra-orbital.

(3) One to the orbit where it forms the orbital sinus.

(4) One running slightly posteriorly and upwards to the mid dorsal line, where it is in connection with a similar vessel from the other side.

(5) One running slightly posteriorly and downwards to the margin of the upper jaw, behind the eye, to join a large sinus-like vessel in connection with the inferior jugular vein.

Though vessels must be present bringing back blood from the brain and entering presumably the superior jugular, I have been unable to detect such, though by means of injection the above described branches were traced with comparatively little difficulty and also, as described previously, the cerebral arteries.

(2) *Inferior jugular vein* (figs. 6, 15, and 16).

This is connected with the Ductus Cuvieri at the point described above. From this it runs slightly outwards, lying close to the surface of the hinder wall of the fifth cleft and then runs downwards in this superficial position parallel to the fifth branchial cartilage. Passing more deeply into the body it turns forwards along the ventral side so that its course lies at right angles to the gill arches (fig. 6). Just as it does so it divides into two branches, a larger and a smaller, of which the latter runs slightly dorsalwards and then turns forwards again dorsad of the afferent branchial arteries. The larger one continues its course ventrad of the same vessels.

The smaller deeper-lying vessel receives, before passing dorsad of the fourth afferent artery, a small branch which passes forwards from the anterior wall of the pericardium (fig. 6, *peri. v.*). Dorsad of the arteries it runs along close to the mid ventral line in the region of the mesobranchial cartilages.

The large vessel runs forwards crossing at right angles the afferent arteries (fig. 6) and receiving from each arch a small nutrient branchial vein *(nu. br. v.)*. Just anteriorly to the level of the first arch it bends outwards and then passes upwards along the outer surface of the flattened cerato-hyal cartilage immediately anterior to the hyoidean artery, the relationship of which has been previously described.

It then turns round the angle of the jaw, swelling out as it does so into a sinus which may be called the *hyoidean sinus.* A branch *(mandibular vein)* joins it from the lower jaw after which it passes forwards to a point beneath the orbit. Here it divides into (1) a sinus-like vessel running into the orbit and forming the *orbital sinus* which is in connection with the sinus belonging to the superior jugular, (2) a *palatine* branch which passes inwards and behind the large palatine teeth and (3) a nasal branch passing directly forwards to the olfactory organ.

F. *Derivatives of the posterior cardinal system.*

Under this head may be considered two important vessels, one on the right and one on the left side of the body. There can be, I think, little doubt but that one of these is the representative of the left posterior cardinal vein of a typical fish; whilst the other may be rightly regarded, judging from its relationships, as intimately associated with a similar right posterior cardinal vein. The significance of this will be discussed later.

In this system we have again an instance of the asymmetrical development of the blood vessels which has been already noticed in connection with the pulmonary arteries and the anterior abdominal system.

(1) *Posterior cardinal of the left side* (figs. 10, 15, and 16).

It was noted when dealing with the caudal vein that this, after passing downwards from the hæmal arch, divides into two branches, between the kidneys, of which branches the right is considerably larger than the left. The left branch into which open two revehent branches from the kidney of its side passes onwards to the left flat band-like testis (or to the ovary). Accompanied by the artery, it runs along the whole length of the latter on the inner side close to where the mesentery attaches it to the wall of the intestine (fig. 10). It can be easily injected in either direction.

Traced forwards the artery and vein are found to run onwards to the very anterior end of the body cavity above the level of the liver. From the testis, or ovary, as the case may be, the vein receives numerous branches during its course. Just beyond the anterior end of the body cavity the artery which lies to the outer side of the vein crosses dorsad of the latter and runs forwards to join the brachial artery of its own side close to the dorsal aorta, as previously described.

The vein runs on forwards and at the same time slightly downwards giving off a curious anastomotic branch to the brachial artery (figs. 2 and 15, *x.*), beneath which it passes until it reaches the point at which the superior jugular and the subscapular veins join together to open into the Ductus Cuvieri (fig. 15). It then falls into the vessel formed by the union of these two.

There can, I think, from its relationship—viz., its origin from the caudal vein, connection with the kidney and final opening into the Ductus Cuvieri—be no doubt but that we are here dealing with a posterior cardinal vein, though perhaps slightly modified, such as is characteristic of the piscine type.

It may be noticed, however, that in contrast to what obtains in such forms as Raja, Squatina, Squalus, Spinax, and Mustelus,* *the caudal and posterior cardinal veins are directly continuous* and that though a renal portal system is formed this does not intervene, in Ceratodus, between the two veins mentioned. We have, in fact, a renal portal of the amphibian type existing side by side with a posterior cardinal system of a primitive piscine nature.

(2) *Inferior vena cava* (figs. 10 and 16).

In Dr. Günther's brief account, he described the vessel now under consideration as a single "vena cava posterior."† The vessel called above the posterior cardinal of the left side he, however, described as "a very strong vein from the left testicle, which corresponds in situation and function to the main trunk and might be called a left vena cava posterior; but the currents of blood in the two run in opposite directions—that of the right (main) trunk running towards the head, that of the left towards the tail." It will be seen that this account corroborates his with regard to the right or main trunk, and differs from him with regard to the left.

The right branch of the caudal vein is a very large one—the largest vessel indeed in the body of Ceratodus: it passes from the anterior end of the kidney directly into the testis (or ovary), which is shorter on the right than on the left side (fig. 16). Both vein and artery, instead of, as on the left side, passing on to the anterior end of the body cavity, dorsad of the liver, run directly from the testis into the elongated right lobe of the liver. In this the artery runs forwards and then turns dorsalwards to join the cœliaco-mesenteric artery just before it gives off the enteric branch to the intestine.

The vein runs straight through the substance of the liver receiving in its course (fig. 17) many small branches: reaching the median part it opens directly into the sinus venosus by a wide aperture on either side of which lies the opening of one of the hepatic veins. Its course from between the kidneys and then forwards through the body cavity and finally through the substance of the liver into the median part of the sinus venosus, as well as its relationship to the hepatic veins are unmistakable points of resemblance between it and an inferior vena cava typical of Amphibia.

(3) *Vertebral vein of right side* (figs. 8 and 16, *r. vert. v.*).

This is evidently a vein recognised by Dr. Günther, who says "the second artery" (*i.e.*, of the left side, the brachial artery of the above description) "forms a

* Parker, *loc. cit.* p. 704.
† *Loc. cit.* p. 539.

very peculiar anastomosis with the left vena cava superior. This last anastomosis is also indicated on the right side; but its arrangement is somewhat different; namely, the right vena cava superior emits a branch inwards towards the aorta, running parallel with the arteria coeliaca. The branch is widely open at its origin, and colouring matter can easily be injected into its cavity from the vena cava; but the canal is gradually obliterated and closed entirely before it reaches the aorta. Probably there exists an open communication between the vein named and the aorta at an early period of life."

The branch in question (fig. 8, *r. vert. v.*), which appears to exist only on the right side, is formed by the union of several small branches from the side of the vertebral column behind the region of the cœliac artery. It crosses the latter and then immediately turns downwards by the side of the brachial artery receiving as it does so branches from the outer surface of the membrane between the ribs lying just behind the latter artery. It then crosses beneath the brachial artery and runs downwards, inwards and forwards, increasing rapidly in size till it joins the trunk formed by the union of the jugular and subscapular vein in exactly the position in which, on the left side, the posterior cardinal joins this.

We have, I believe, in this vein, the proximal part of which is abnormally large in proportion to its area of distribution, the remnant of the anterior part of the right posterior cardinal, which now simply serves to carry back blood from the anterior vertebral and costal region of the right side.

G. *Brachial veins* (figs. 8, 15, and 16).

The blood from each of the anterior limbs is returned to the heart by a vessel which runs superficially from the anterior aspect of the limb upwards in the hinder wall of the gill cavity till it falls into the short trunk running between the proximal end of the superior and inferior jugular veins. It receives a small branch from the dorsal face of the median coracoid portion of the limb girdle.

H. *Cutaneous vein system* (figs. 8, 15, and 16).

In Mustelus amongst Plagiostomes Parker has described the presence of paired lateral cutaneous and median dorsal and ventral cutaneous veins. In Ceratodus there is no trace of a dorsal cutaneous vein and though in the anterior part of the trunk ventrally a vein lies somewhat close to the external surface, this has been shown above to be a direct forward prolongation of pelvic veins and hence cannot be regarded as equivalent to a cutaneous vein.

On the other hand, the lateral cutaneous veins are very well developed, and their course easy to follow after injection. Each runs superficially to the muscles at the level of the lateral line from the hinder border of the scapula to the posterior end of the body, its calibre becoming very small in the tail region. It receives small branches from the muscles along its course and at the shoulder girdle passes inwards behind the lower end of the scapula where this joins the coracoid. At this point it unites with the *subscapular vein* (figs. 8 and 15, *s.-sc. v.*). At the point of union is a sinus-like structure into which enter a number of branches from the muscles lying immediately behind the scapula. The subscapular vein passes downwards (fig. 15) and slightly forwards, thus running roughly parallel to the coracoid and beneath the latter. It then joins the main trunk, into which the brachial and superior jugular veins fall close to the entrance of the latter.

At about one-third of the distance between the hind limb and the end of the tail the cutaneous vessel of each side sends inward a well-marked branch which passes between two hæmal arches and opens into the caudal vein (fig. 16).

There is a striking resemblance between Mustelus and Ceratodus in this vein, which in both cases runs at the same level, opens anteriorly into the subscapular sinus and posteriorly communicates with the caudal vein.

V.—GENERAL CONSIDERATIONS.

A. *The arterial system.*

In certain respects this shows a resemblance to that of Amphibia and in others to that of Elasmobranch fishes.

The especial amphibian features are (1) the origin of the branchial afferent vessels almost simultaneously from the anterior end of the conus, (2) the manner of union of the epibranchial arteries to form the dorsal aorta and (3) the origin on either side of a pulmonary artery from the fourth epibranchial artery. In these respects it is very closely similar to an amphibian in which both lungs and gills are present.

Marshall and Bles have pointed out* that in the case of *Rana temporaria* the pulmonary artery is developed at a very early stage and further that the lungs appear very early and are used for a considerable time simultaneously with the gills.

* *Loc. cit.* pp. 222 and 263.

Probably in the earliest forms in which lungs were developed as respiratory structures the mode of life was very similar to that of Ceratodus. The animal lived in water and at first at any rate and possibly for long the lungs were accessory organs used normally together with the branchiæ. They were functional throughout life and in the early life of the tadpole of Rana we have reproduced, so far as the respiratory system is concerned, a condition which is normal to Ceratodus throughout its whole life.

The development in Ceratodus of a single instead of a double lung as in Protopterus has brought about certain differences in these two forms in the pulmonary arteries. Both forms, however, have two—a left and a right one—present* and in both the left passes to the ventral surface, and the right to the dorsal surface.

In the arteries also it may be noted as an interesting point that there is present a vessel passing forwards from the ventral end of the efferent artery of the first branchial arch which is evidently directly comparable to the lingual artery of Amphibia, which, as previously mentioned, Marshall and Bles have shown to arise from the same vessel in *Rana temporaria*.

In certain respects, however, the arterial system shows close relationship to that of Elasmobranchs.

The most important of these are, (1) the presence of two efferent arteries in each arch—an anterior and a posterior one. This is a very characteristic elasmobranch feature. Apparently in the development of Rana there is no trace of anything corresponding to the posterior of the two efferent arteries, the single one of the latter forms being the homologue of the larger and, in the Elasmobranchs, earlier developed anterior vessel. Ceratodus appears, however, to be more primitive than the adult Elasmobranch since throughout life the efferent vessels of the same arch unite to form an epibranchial, a condition which only obtains in the latter forms during early embryonic stages.

(2) The origin and distribution of the carotid arteries. Whilst in Elasmobranchs, Ceratodus, and Amphibia a carotid vessel arises from what may be regarded as the forward prolongation of the dorsal aorta on each side, in the two former it is a branch connected ultimately with the vessel in the hyoidean arch which

* Zur Anatomie und Physiologie von *Protopterus annectens*. Berichte der Nat. Gesell. Freiburg, 1888. W. N. Parker. I am unfortunately unable to refer to Hyrtl's paper on *Lepidosiren paradoxa*, but according to Professor W. N. Parker the latter has shown that two pulmonary arteries are present in this form. A curious mistake may here be noted in the English translation of Wiedersheim's "Comparative Anatomy of Vertebrates." On page 281 it is stated, "in Ceratodus the lung is supplied with blood from the coeliac artery." This mistake has evidently been copied from Günther's original paper and does not occur in the original German work, nor does it correspond to the figure on page 280 of the English translation.

carries arterial blood to the brain and gives rise to the cerebral arteries. There are certain differences in the origin of this in Elasmobranchs and Ceratodus, already noticed and due to the presence in the former and absence in the latter of a pseudobranch; but whilst the carotid system of these forms is undoubtedly closely similar the vessels in both differ considerably from those of Amphibia with which it is not possible at present to exactly homologize them.

(3) The presence in Ceratodus of an intra-intestinal artery associated with the development, as in Elasmobranchs, of a spiral fold in the intestine.

(4) The presence in Ceratodus, as in Elasmobranchs (Mustelus), of anterior spermatic and oviducal arteries which pass off from the dorsal aorta not far behind the entrance of the last pair of epibranchial arteries.

B. *The veins.*

In the veins even still more notably than in the arteries we find a remarkable mixture of piscine and amphibian types and with this is associated a lack of symmetry on the two sides of the body.

So far as the cardinal system is concerned, the vessels representing the anterior cardinal—superior and inferior jugular veins—are closely similar to those of Elasmobranchs and are characterised by the presence of large sinuses and of anastomotic branches—a fact to which Prof. Parker has drawn attention in Mustelus.* In fact, it may be said that, so far as the vessels, both veins and arteries of the head region are concerned, Ceratodus is typically piscine.

Again, in the presence of a very distinct lateral cutaneous vein which has posterior connections with the caudal vein and opens anteriorly into the subscapular sinus, whence a large subscapular vein runs down to the Ductus Cuvieri on each side, we see a point of nearly precise agreement with Mustelus. On the other hand, neither dorsal nor ventral cutaneous branches appear to be present in Ceratodus.

A further strong point of agreement is the presence of a well-developed intra-intestinal vein in connection, as in Elasmobranchs, with the spiral fold. This vessel has now been shown to be present in Elasmobranchs, Holocephali (Callorhynchus), and Dipnoi (Ceratodus).

Whilst the above veins reveal piscine affinities, there are others which show that Ceratodus has developed to a certain extent along lines at all events parallel to those of the Amphibia. This is shown in the development of (1) the inferior vena cava system and (2) the anterior abdominal system to which attention may now be drawn.

* *Loc. cit.* p. 721.

The caudal vein passing forwards runs downwards to the kidneys between which it divides into two main branches running forwards one on either side of the mid line. It receives from the kidney two branches on either side which carry to it the blood from the renal portal circulation.

This direct connection between the caudal vein and vessels which must be regarded as derivatives of the posterior cardinal system is a feature calling to mind the embryonic stages of Amphibia and Elasmobranchs and the adult condition in Cyclostomes.

As shown previously the left forward-running branch receives blood from the reproductive glands and runs on to open into the Ductus Cuvieri of its own side. The right vessel is, however, much larger than the left, runs forwards nearer to the middle line and finally passes through the substance of the liver receiving small branches from this and then *opens into the sinus venosus between the two hepatic veins.* Professor W. N. Parker,* in dealing with Protopterus has stated that the vessels which have hitherto been described as "venæ cavæ posteriores" are not such but correspond to modified "venæ cardinales posteriores." In Ceratodus Dr. Günther spoke of the vessel of the right side as a vena cava posterior and in doing so he was, I think, perfectly correct. At the same time it may, I think, be said that *in Ceratodus we have both a posterior cardinal vessel and a posterior (or inferior) vena cava present.* It is true that the vessel, called in the previous account the left posterior cardinal, lies deeper in the body cavity than it normally does in fishes but this comparatively slight modification in position is not sufficient to outweigh the evidence of its posterior connection with the caudal vein, its relation to the kidneys and its anterior termination in the Ductus Cuvieri.

The vessel of the right side to which the name of inferior vena cava is here given presents greater difficulty in the determination of its homology but, judging from its relationship to the caudal vein and to the kidney and reproductive organ of its own side (identically the same as in the case of the left vessel), together with the remarkable course of its anterior part through the liver and its subsequent entrance into the middle of the sinus venosus between the hepatic veins, we are forced to regard it as the representative of the inferior vena cava of Amphibia (or other forms), which has been developed in close relationship to the right posterior cardinal vein. It appears as if in Ceratodus, as also in Pisces generally, the right posterior cardinal became much larger than the left and as if in Ceratodus it became in part modified to form the inferior vena cava. It is interesting to note in this connection the account given by Götte (according to Balfour†) of the development of the

* *Loc. cit.* p. 19.

† Embryology (Memorial edition), Vol. III. p. 655.

inferior vena cava in Amphibia. Subsequently to the formation of the two posterior cardinal veins *the anterior part of the inferior cava is found independently of but soon unites behind with the right posterior cardinal vein.* In the Amphibia the two cardinals unite backwards for some distance to give rise to the posterior section of the vena cava inferior between the two kidneys. This long union does not obtain in Ceratodus where the kidneys are placed very posteriorly and the reproductive organs are long band-like structures stretching a long distance forwards. They unite, however, between the kidneys where the venæ renales revehentes enter.

In Ceratodus, further, the two vessels which on each side open into the single large vessel between the kidneys must be regarded as *venæ renales revehentes,* which carry back from the kidneys blood taken to the latter by the posterior trunk, the iliac, and the intercostal veins.

Except for the more posterior point of fusion of the two cardinals, Ceratodus presents us with a condition closely comparable to that seen, according to Götte, during the development of Amphibia. In the latter the anterior portions of the cardinal veins atrophy whilst in Ceratodus the left persists throughout life and a remnant of the right remains, carrying back blood from the vertebral and costal region in the anterior part of the trunk. In this way Ceratodus presents a remarkable union of piscine and amphibian characters.

The anterior abdominal system, as described previously, is again one of the most striking features in the venous system of Ceratodus. Whether or no the vessels described here as pelvic are homologous with the lateral veins of Elasmobranchs they have the same relationship to the vein of the hind limb of Ceratodus as have the pelvic in an amphibian to the femoral veins. Götte, again, has described the iliac vein in the development of Amphibia as uniting at first both with the median vessel formed by the posterior union of the cardinals and also with a longitudinal vessel on the outer border of the kidney. The latter union is strikingly similar to the one (fig. 19) which occurs in the case of the hind limb vein in Ceratodus. The latter vessel divides into two of which on each side of the body one runs forwards, unites with its fellow and then the median vessel thus formed runs forwards to open into the sinus venosus. The median vessel is distinct though comparatively a small one and its formation by union of the pelvic veins and subsequent entrance into the sinus venosus prevent our regarding it as the homologue of the ventral cutaneous vein in Elasmobranchs. In Amphibia the anterior abdominal vein is at first a double one, *each part entering the sinus separately* and though there is no trace anteriorly, in the adult Ceratodus, of this double nature, still its origin and termination justify us in applying to it the name of anterior abdominal.

DESCRIPTION OF PLATES.

REFERENCE LETTERS.

A.—Dorsal communicating branches between the efferent branchial arteries. *Ant. abd. v.*—Anterior abdominal vein. *Ant. car. art.*—Anterior carotid artery. *Ant. vert. art.*—Anterior vertebral artery. *Au.*—Auricle.

Br. 1 (fig. 20)—First branchial hemibranch. *Br. 1, 2, 3, 4*—Branchial arches. *Br. art.*—Brachial artery. *Br. v.*—Brachial vein.

C. a.—Conus arteriosus. *C. c.*—Circulus cephalicus. *Clo. art.*—Cloacal artery. *Clo. v.*—Cloacal vein. *Cœl.-mes.*—Cœliaco-mesenteric artery. *Cor. art.*—Coronary artery. *Corac. art.*—Coracoid artery. *Cost. art.*—Costal artery.

D. int. art.—Dorsal intestinal artery. *D. int. v.*—Dorsal intestinal vein.

Eff 1, 2, 3, 4—Efferent branchial arteries. *Epi. 1, 2, 3, 4*—Epibranchial arteries.

Gl.—Glottis.

Hep. art.—Hepatic artery. *H. p. v.*—Hepatic portal vein. *Hy. art.*—Hyoidean artery. *Hy. br.*—Hyoidean hemibranch. *Hypo. art.*—Hypobranchial artery.

I. v. c.—Inferior vena cava. *Ent. art.*—Enteric artery. *Int.-int. art.*—Intra-intestinal artery. *Int.-int. v.*—Intra-intestinal vein. *Inf. jug.*—Inferior jugular vein.

L. ant. car.—Left anterior carotid artery. *L. ant. sperm. art.*—Left anterior spermatic artery. *L. br. art.*—Left brachial artery. *L. cut. art.*—Lateral cutaneous artery. *L. d. c.*—Left ductus cuvieri. *L. il. art.*—Left iliac artery. *L. hep. v.*—Left hepatic vein. *L. post. car.*—Left posterior carotid artery. *L. post. card.*—Left posterior cardinal vein. *L. post. sp. art.*—Left posterior spermatic artery. *L. pul. art.*—Left pulmonary artery. *L. ren. art.*—Left renal artery. *L. sc. v.*—Left sub-scapular vein. *Lat. cut. v.*—Lateral cutaneous vein. *Ling. art.*—Lingual artery.

Mand. v.—Mandibular branch of inferior jugular vein. *Mes.*—Mesentery. *Musc. art.*—Branch from hypobranchial artery to muscles of ventral surface.

Nas. v.—Nasal branch of the inferior jugular vein. *Nu. br. v.*—Nutrient branchial veins.

Occ. art.—Occipital artery. *Œs.*—Œsophagus. *Œs. art.*—Œsophageal artery. *Operc. art.*—Branch from hyoidean artery to inner face of operculum. *Operc. v.*—Opercular branch of inferior jugular vein. *Orb. art.*—Orbital artery. *Orb. 1*—Branch from superior jugular vein to orbit. *Orb. 2*—Branch from inferior jugular vein to orbit.

Pal. art.—Palatine artery. *Pal. v.*—Palatine vein. *Pel.*—Anterior process of pelvic plate. *Peri. art.*—Pericardial artery. *Pul. v.*—Pulmonary vein. *Post. cer. art.*—Posterior cerebral artery. *Post. int. art.*—Posterior intestinal artery.

R. ant. car.—Right anterior carotid. *R. ant. sp. art.*—Right anterior spermatic artery. *R. br. v.*—Right brachial vein. *R. d. c.*—Right ductus cuvieri. *R. il. art.*—Right iliac artery. *R. il. v.*—Right iliac vein. *R. inf. jug.*—Right inferior jugular vein. *R. lat. cut. v.*—Right lateral cutaneous vein. *R. post. car.*—Right posterior carotid artery. *R. ren. art.*—Right renal artery. *R. post. sp. art.*—Right posterior spermatic artery. *R. sup. jug.*—Right superior jugular vein. *R. vert. v.*—Right vertebral vein. *Ren. port. v.*—Renal portal vein.

S.-sc. v.—Subscapular vein. *S. v.*—Sinus venosus. *Sp. f.*—Spiral fold. *Sup. jug.*—Superior jugular vein.

V.—Ventricle. *V. int. art.*—Ventral intestinal artery. *V. int. v.*—Ventral intestinal vein.

X. (fig. 15)—Anastomotic branch between the brachial artery and the left posterior cardinal vein.

Y. (fig. 20)—Gill-rakers.

PLATE I.

Fig. 1.—Diagrammatic drawing of the heart and main blood vessels, as seen from the ventral surface.

Fig. 2.—Diagrammatic side view of the branchial arteries and the dorsal aorta, together with the main vessels which arise anteriorly from the latter.

Fig. 3.—Diagrammatic drawing of the afferent and efferent branchial arteries, together with the epibranchial arteries and the main arteries which arise from these vessels on the right side.

Fig. 4.—Semi-diagrammatic drawing of a portion of a gill arch, showing the branchial laminæ and the position of the afferent and efferent arteries as seen in transverse section of the arch.

PLATE II.

Fig. 5.—Diagrammatic drawing of the dorsal ends of the efferent branchial arteries and the epibranchial arteries, together with the main vessels arising from these. This shows especially the origin and course of the carotid arteries.

Fig. 6.—Semi-diagrammatic drawing to show the relative positions of the afferent branchial arteries, the vessels arising ventrally from the efferent branchial arteries and the inferior jugular vein.

Fig. 7.—Diagrammatic drawing of the veins from the hinder part of the body and the hind limbs which carry blood to the kidneys, together with the origin of the pelvic veins which unite anteriorly to form the anterior abdominal system.

Fig. 8.—Diagrammatic drawing of the veins which enter the ductus cuvieri of the right side.

PLATE III.

Fig. 9.—Side view of the intestine, of which the wall of one side (the right) has been cut away to show the spiral fold. Whilst the drawing is semi-diagrammatic, the coiling of the fold and the positions of the larger vessels were drawn from an actual specimen. Three complete coils of the fold are exposed anteriorly, and posterior to these the six transverse series of blood vessels indicate the line followed by the spiral fold in the specimen. This drawing is intended to show the distribution of the arteries and veins in the intestine.

Fig. 10.—Diagrammatic drawing to show the arterial vessels which pass through the kidney and the venous vessels so far as the latter are connected with the caudal, the posterior cardinal of the left side and the inferior vena cava. The left kidney and testis are drawn in outline; the right hand ones are shaded.

Fig. 11.—The enteric artery and hepatic portal veins, with the three main branches into which each divides.

Fig. 12.—Diagrammatic transverse section across the intestine to show the positions of the arteries and veins.

Fig. 13.—Diagrammatic transverse section across the body of Ceratodus in the middle of the trunk region to show the relative positions of the arteries and veins.

PLATE IV.

Fig. 14.—Diagrammatic drawing of the arterial system: seen from the dorsal side.

Fig. 15.—Semi-diagrammatic drawing of the venous system of the anterior part of the body.

Fig. 16.—Diagrammatic drawing of the venous system: seen from the ventral side.

PLATE V.

Fig. 17.—Drawing (from dissection) of the heart, liver (cut open), lungs and termination of the œsophagus. The latter has been pulled over to the left side. This drawing shows the sinus venosus cut open and the entrance into it of the ductus cuvieri, anterior abdominal vein, hepatic veins and inferior vena cava. On the ventral surface of the lung the left pulmonary artery is seen with its two branches and the two branches of the pulmonary vein, which unite to form a single vessel running forwards to the left auricle. The ventricle is pulled forwards.

Fig. 18.—Semi-diagrammatic drawing (from dissection) of the œsophagus and anterior part of the lung from the ventral surface. The œsophagus is cut open to show the glottis, and the course of the pulmonary vein and arteries is shown.

Fig. 19.—Drawing (from specimen) of the kidney of the left side, with the venous vessels which carry blood to it. The kidney is drawn over towards the median line, and some of the lobes are lifted up to show the course of the vein, which runs along the outer surface of the kidney and into which open the intercostal and renal portal vein.

Fig. 20.—Drawing (from specimen) of the hyoidean and first branchial hemibranch, together with the remaining gills.

Fig. 21.—Drawing (from specimen) of two hemibranchs, one on either side of the second branchial cleft, to show the continuity both dorsal and ventral of the branchial laminæ.

THE PLIOCENE MOLLUSCA OF NEW ZEALAND.

By F. W. Hutton, F.R.S., Professor of Geology in Canterbury College, Christchurch.

(Plates vi.-ix.)

Fossiliferous beds of Pliocene age are found in New Zealand only in the southern and eastern parts of the North Island. Commencing near Patea, on the south coast, they form a band passing eastwards through Wanganui to the Manawatu Gorge in the Ruahine Mountains. On the eastern side of these mountains Pliocene beds again appear and run along their eastern flanks to Napier and the Mohaka River in Hawkes' Bay*. North of this they are not known with any certainty. On the western side of the mountains these beds are said by Mr. James Park to lie conformably on supposed Miocene rocks†, which occupy the space between the volcanic systems of Taranaki and Ruapehu, and continue to the northern part of the Ruahine Mountains; but on the eastern side of these mountains the two are unconformable, and this appears to be also the case on the west coast north of New Plymouth.‡

About 64 p.c. of the Pliocene mollusca are also found in the Miocene rocks, but the Pliocene is characterised by (1) the presence of *Trophon, Columbella, Turricula,* and *Mytilicardia;* (2) by the absence of *Peristernia, Nassa, Mitra, Conus, Limopsis* and *Cucullæa;* (3) by the small size of the species of *Turritella, Dentalium, Cytherea, Cardium, Pecten* and *Ostrea.*

From the recent fauna that of the Pliocene is distinguished by having from 23 to 37 p.c. of the species extinct—that is, so far as is at present known—and by the presence of the following genera which are not known to live now in the New Zealand seas, viz.: *Ringicula, Oliva, Sigaretus, Eulima, Eulimella, Admete, Cerithium, Risella, Lutraria, Loripes, Poroleda* and *Perna.* But perhaps those genera which contain minute species only may yet be detected in the living state.

The examination, however, of a large collection of shells made indiscriminately does not give the impression of so great an age as would be implied by the presence

* Trans. N.Z. Institute, Vol. XVIII. p. 336, pl. xii.

† Reports of Geological Explorations, 1886-7, p. 28.

‡ Trans. N.Z. Institute, Vol. XVIII. p. 343.

of so many extinct forms; for the recent species are far more common than the extinct ones, and the latter are more local and often rare. We seem to be dealing with the remains of an earlier fauna disappearing rapidly before the conquering host of the recent fauna, which had invaded New Zealand some time previously; and if this idea is correct we might expect to find some of the Pliocene forms which are now extinct on the shores of New Zealand still lingering in the outlying islands. This appears to be the case with *Natica vitrea, Cancellaria trailli, Trochus chathamensis* and *Dosinia grayi*, of the Chatham Islands; but further investigation is necessary, for at present the only collections sent from the Chatham Islands have been dead shells picked up on the beach.

Class GASTEROPODA.

Genus AMPHIBOLA.

AMPHIBOLA AVELLANA, Chemnitz, Conch. Cab. V. figs. 1919-1920; *Ampullacera avellana*, Quoy and Gaimard, Voy. Astrolabe, Zool. II. p. 196, pl. xv. figs. 1-9; *Amphibola australis*, Woodward, Manual of Mollusca, pl. IX. fig. 33.

Locality.—Napier.

Genus RINGICULA.

RINGICULA UNIPLICATA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 313.

Shell minute, ovate, finely transversely striated. Whorls four, those of the spire small and smooth. Aperture rather narrow, slightly obliquely notched in front; the outer lip thickened and reflexed; columella with the anterior plication much stronger than the posterior. Length 2mm.

Locality.—Petane.

Genus TORNATINA.

TORNATINA PACHYS, Watson, Linn. Soc. Journal, Vol. XVII. p. 331.

Locality.—Wanganui and Petane.

Genus TORNATELLA.

Key to the species.

Aperture more than half the length of the shell ... ... *T. alba.*
,, less than half the length of the shell ... ... *T. sulcata.*

TORNATELLA ALBA, Hutton, Cat. Marine Moll. of N.Z. p. 51 (*Buccinulus*).

(Plate VI. fig. 2.)

Whorls seven, rather deeply transversely grooved and lightly longitudinally striated, the striæ showing distinctly in the grooves. Columella with a broad double anterior fold and a smaller posterior one. Length 15 mm.; breadth 7 mm.

Locality.—Wanganui.

TORNATELLA SULCATA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 319, pl. XVIII. fig. 15. (*Odostomia*).

(Plate VI. fig. 1.)

Shell ovate, spirally grooved. Whorls eight, those of the spire with 5 to 7 narrow grooves; the body whorl with 18 to 20, crossed by longitudinal growth lines; suture impressed. Aperture ovate; columella with a single anterior oblique fold. Length 25 mm.; breadth 11 mm.

Locality.—Wanganui.

Genus CYLICHNA.

CYLICHNA ARACHIS, Quoy and Gaimard, Voy. Astrolabe, Zool. II. p. 361, pl. XXVI. figs. 28-30 (*Bulla*); *Cylichna striata*, Hutton, Cat. Marine Moll. of N.Z. p. 52.

Locality.—Petane.

Genus MUREX.

Key to the species.

Varices	more than three, each with 5 or 6 spines ...	*M. neozelanicus.*
,,	more than three, each with 7-13 spines ...	*M. octogonus.*
,,	more than three, without spines	*M. espinosus.*
,,	three only	*M. angasi.*

MUREX NEOZELANICUS, Quoy and Gaimard, Voy. Astrolabe, Zool. II. p. 529, pl. XXXVI. figs. 5-7; Tryon, Man. Conch. II. pl. XXIX. fig. 268.

Locality.—Wanganui, Petane, Matapiro.

MUREX OCTOGONUS, Quoy and Gaimard, l.c. II. p. 531, pl. XXXVI. figs. 8-9; Tryon, l.c. II. pl. XXX. fig. 134.

Locality.—Wanganui.

MUREX ESPINOSUS, Hutton, Trans. N.Z. Inst. Vol. XVIII. p. 333.

(Plate vi. fig. 3.)

Shell fusiform, with a moderate canal and no spines. Whorls $5\frac{1}{2}$-$6\frac{1}{2}$, the first embryonic, the others spirally and longitudinally ribbed. Longitudinal ribs rounded, distant, 8 or 9 on a whorl; spiral ribs strong, scaly, close, about 10 on the penultimate and 25-30 on the body whorl, those just below the suture smaller than the others. Aperture oval, rather suddenly contracted into the moderate and slightly bent canal, which is more or less closed. Length 30mm.; breadth 15mm.

Locality.—Petane, Matapiro.

MUREX (PTERONOTUS) ANGASI, Crosse, Jour. de Conch. XI. p. 86, pl. i. fig. 5 (*Typhis*); Tryon, l.c. II. pl. xl. fig. 522; *Typhis zealandica*, Hutton, Cat. Tertiary Moll. of N.Z. p. 2.

Locality.—Wanganui.

Genus TROPHON.

Key to the species.

A. Longitudinal sculpture thin, varices.

Varices distant, canal long ... ... *T. ambiguus.*

Varices close, canal short

Spirals distant, narrow ... ... *T. stangeri.*

Spirals close, broad ... ... *T. cheesemani.*

B. Longitudinal sculpture broad, forming ribs (*Kalydon*).

Ribs absent on body whorl ... ... *T. expansus.*

Ribs present on body whorl.

Spirals close, longitudinals 18 in a whorl ... *T. plebeius.*

Spirals close, longitudinals 10-12 in a whorl... *T. duodecimus.*

Spirals distant, longitudinals 12 in a whorl ... *T. crispus.*

TROPHON AMBIGUUS, Philippi, Abbild. *Fusus*, pl. i. fig. 2; Tyron l.c. II. pl xxxiii. fig. 365; Homb. and Jacq. Voy. Pôle Sud, Zool. V. p. 109, pl. xxv. figs. 13-14.

Locality.—Wanganui, Petane, Matapiro.

TROPHON STANGERI, Gray, in Dieffenbach's "New Zealand," II. p. 230 (*Fusus*); *Purpura rugosa*, Quoy and Gaim. l.c. II. p. 569, pl. xxxviii. figs. 19-21; Tryon l.c. II. pl. li. figs. 112 and 122: *Purpura quoyi*, Reeve, Conch. Icon. fig. 71: *Murex spiratus*, Adams, P.Z.S. 1863, p. 429; Tryon, l.c. III. pl. xxxiii. fig. 354.

Locality.—Wanganui.

TROPHON CHEESEMANI, Hutton, Trans. N.Z. Inst. Vol. XV. p. 131 (*Polytropa*).

(Plate VI. fig. 4.)

Shell small, fusiform. Whorls five; those of the spire small, with a single spiral rib; body whorl large with five spiral grooves between the ribs, the ribs broad and smooth, the grooves narrow and transversely striated. Aperture moderate, contracted in front into a short, open, slightly twisted canal; four or five short, well developed teeth inside the outer lip. Length 15 mm.; breadth 9 mm.

Locality.—Wanganui.

TROPHON EXPANSUS, Hutton, Trans. N.Z. Inst. Vol. XV. p. 410.

(Plate VI. fig. 5.)

Shell ovate, spire moderate acute. Whorls five or six, spirally grooved, the grooves narrower than the ribs; about 26 grooves on the body whorl, crossed by undulating laminæ of growth worn smooth. Aperture ovate, wide, slightly angled behind; outer lip expanded; columella rounded, with a small posterior canal; anterior canal very short and recurved. Length 20 mm.; breadth 10 mm.

Locality.—Wanganui, Petane, Matapiro.

TROPHON PLEBEIUS, Hutton, Cat. Marine Moll. of. N.Z. p. 9 (*Fusus*).

(Plate VI. fig. 6.)

Shell small, fusiform. Whorls six or seven, spirally grooved and finely longitudinally plaited. Aperture oval, anterior canal moderate, bent slightly to the left; outer lip grooved in the adult. Length 21 mm.; breadth 10 mm.

Locality.—Wanganui, Petane, Matapiro.

TROPHON DUODECIMUS, Gray, in Dieffenbach's "New Zealand," II. p. 230 (*Fusus*); *Kalydon duodecimus*, Hutton, Trans. N.Z. Inst. Vol. XVI. p. 220.

(Plate VI. fig. 7.)

Shell small, fusiform, with about twelve broad rounded longitudinal ribs, which are crossed on the body whorl by about 12 to 18 narrow spiral ribs. Aperture oval; canal moderate, nearly straight. Length 14 mm.; breadth 6 mm.

Locality.—Wanganui, Petane, Matapiro.

TROPHON CRISPUS, Gould, Pro. Boston Soc. Nat. Hist. III. p. 141 (*Fusus*) (?).

(Plate VI. fig. 8.)

Shell small, fusiform. Whorls five, with about twelve longitudinal rounded ribs which are crossed on the body whorl by 8 or 10 spiral ribs, the grooves between which are transversely striated, by growth laminæ. Aperture oval, the outer lip grooved inside; canal short and straight. Length 7 mm.; breadth 4 mm.

Locality.—Wanganui, Petane, Matapiro.

Distinguished from the last species by the more distant spiral ribs, the shorter canal and smaller size. It may be distinct from *Fusus crispus* of Gould, which comes from Terra del Fuego.

Genus FUSUS.

FUSUS AUSTRALIS, Quoy and Gaimard, Voy. Astrolabe, Zool. II. p. 495, pl. XXXIV. figs. 9-14; Tryon, l.c. III. pl. XXXIV. fig. 113.

Locality.—Wanganui.

FUSUS SPIRALIS, Adams, Pro. Zool. Soc. 1855, p. 221 (?); *Fusus pensum*, Hutton, Cat. Marine Moll. of N.Z. p. 8.

(Plate VI. fig. 9.)

Shell fusiform, elongated. Whorls ten, carinated and spirally ribbed; the keel nodulose or subnodulose, with three narrow spiral ribs behind it and two in front on the spire whorls. Aperture broadly ovate, suddenly narrowed into the canal, which is long and straight. Length 60 mm.; breadth 18 mm.

Locality.—Wanganui, Petane.

Genus TARON.

TARON DUBIUS, Hutton, Jour. de Conch. 1878, p. 18 (*Trophon*); *Taron dubius*, Trans. N.Z. Inst. Vol. XVI. p. 227.

(Plate VI. fig. 10.)

The body whorl has twelve spiral ridges, and usually nine or ten obsolete longitudinal ribs at the posterior end. Aperture more than half the length of the shell. Length 17 mm.; breadth 10 mm.

Locality.—Wanganui. Rare.

Genus SIPHONALIA.

Key to the species.

Whorls not nodose, canal produced	... ...	*S. mandarina.*
,, not nodose, canal short	... ...	*S. cingulata.*
,, nodose, canal long	... ...	*S. dilatata.*
,, nodose, canal short	... ...	*S. nodosa.*

SIPHONALIA (?) CINGULATA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 315.

Shell small, rather thin, fusiform, the spire acute but shorter than the body whorl, not nodose nor ribbed. Whorls 5, the two first embryonic, smooth, usually sharply shouldered; the others rounded, finely spirally striated and delicately marked with growth lines. Suture impressed. Aperture oval, the right lip thin; anterior canal short, nearly straight.

Locality.—Wanganui, Petane.

SIPHONALIA MANDARINA, Duclos, Mag. Zool. VIII.; Tyron, l.c. Vol. III. pl. LVII. fig. 385; *Fusus zealandicus*, Quoy and Gaim. Voy. Astrolabe, Zool. II. p. 500, pl. XXXIV. figs. 4-5.

Locality.—Wanganui, Petane, Matapiro.

SIPHONALIA DILATATA, Quoy and Gaimard, l.c. II. p. 498, pl. XXXIV. figs. 15-16; Tryon, l.c. III. pl. LIV. figs. 356-358.

Locality.—Wanganui, Petane, Matapiro.

SIPHONALIA NODOSA, Martyn, Univ. Conch. *Buccinum*, pl. v.; Tryon, l.c. III. pl. LVI. fig. 377.

Locality.—Wanganui, Petane, Matapiro, Patea.

Variety CONOIDEA, Hutton, *S. nodosa* var. D. Cat. Tertiary Moll. of N.Z. p. 3. Perhaps the same as *Purpura conoidea*, Zittel, Voy. Novara, Palæ. p. 37, pl. XV. fig. 5.

(Plate VI. fig. 11.)

Locality.—Petane, Matapiro.

Genus PISANIA.

Key to the species.

Spiral striations faint, uniform	... ...	*P. lineata.*
,, ,, faint, with distant stronger ones	...	*P. striatula.*
,, ,, strong, uniform	... ...	*P. drewei.*

PISANIA LINEATA, Martyn, Univ. Conch. *Buccinum,* pl. XLVIII.; Tryon, l.c. III. pl. LXXII. figs. 229, 230.

Locality.—Wanganui, Petane.

PISANIA STRIATULA, Hutton; *Cominella striata,* Hutton, Trans. N.Z. Inst. Vol. VII. p. 458, pl. XXI.; (not *Pisania striata,* Gml.).

(Plate VI. fig. 12.)

Shell fusiform. Whorls six or seven, convex, with small spiral ribs and finely spirally striated between the ribs; upper whorls of the spire longitudinally ribbed. Aperture ovate; outer lip grooved inside; columella with a few small teeth at the anterior end; canal rather long, turned slightly backward, and notched. Length 29 mm.; breadth 15 mm.

Locality.—Wanganui, Petane, Matapiro.

PISANIA DREWEI, Hutton, Trans. N.Z. Inst. Vol. XV. p. 410.

(Plate VI. fig. 13.)

Shell fusiform. Whorls six, spirally ribbed, about 22 ribs on the body whorl, the spire whorls finely longitudinally ribbed. Aperture ovate, the posterior canal well marked, anterior canal short, columella obliquely truncated. Length 20 mm.; breadth 11 mm.

Locality.—Wanganui, Petane.

Genus COMINELLA.

Key to the species.

1. Body whorl not longitudinally plicated.
    - Spire considerably longer than aperture ... ... *C. accuminata.*
    - Spire not longer than aperture.
        - Posterior sinus strongly developed ... ... *C. maculata.*
        - ,, ,, slightly developed ... ... *C. virgata.*
2. Body whorl longitudinally plicated.
    - Plications nodulose.
        - Spire shorter than the aperture .... *C. subnodosa.*
        - ,, longer than the aperture ... ... *C. nassoides.*
    - Plications smooth.
        - Plications not continued to suture ... ... *C. lurida.*
        - ,, continued to suture ... . *C. huttoni.*

COMINELLA MACULATA, Martyn, Univ. Conch. *Buccinum*, pl. XLIX.; Tryon, l.c. III. pl. LXXXI. figs. 421, 422.

Locality.—Wanganui, Petane, Matapiro.

COMINELLA SUBNODOSA, Hutton, Trans. N.Z. Inst. Vol. IX. p. 596, pl. XVI. fig. 7.

Locality.—Wanganui, Matapiro.

COMINELLA VIRGATA, Adams, Gen. of Moll. pl. XVI. fig. 6a; *Buccinum lineolatum*, Quoy and Gaim. l.c. II. p. 419, pl. XXX. figs. 14-16; Tryon, l.c. III. pl. LXXXI. fig. 425.

Locality.—Wanganui.

COMINELLA ACCUMINATA, Hutton; *C. elongata*, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 315, pl. XVIII. fig. 5 (not of Dunker).

(Plate VI. fig. 14.)

Shell elongated, the spire much longer than the aperture. Whorls 8, the first $2\frac{1}{2}$ embryonic, polished; the next 3 or 4 with about 10 or 11 longitudinal ribs; the rest smooth. The spiral sculpture is five spiral lines and, after the fourth or fifth whorl, some distant shallow grooves, of which there are about 9 on the body whorl. Aperture ovate, the posterior canal small but well marked; the anterior end deeply notched. Length 33mm.; breadth 13mm.

Locality.—Wanganui.

COMINELLA LURIDA, Philippi, Zeit. f. Malak. 1848, p. 137; Tryon, l.c. III. pl. LXXXI. fig. 439.

Locality.—Wanganui, Petane, Matapiro.

COMINELLA HUTTONI, Kobelt, Cat. d. Gattung *Cominella*, p. 233; *Buccinum costatum*, Quoy and Gaim. Voy. Astrolabe, Zool. III. pl. XXX. figs. 19-20 (not of Lamarck); Tryon, l.c. III. pl. LXXXI. fig. 431.

Locality.—Matapiro.

COMINELLA NASSOIDES, Reeve, Conch. Icon. *Buccinum*, fig. 12; Tryon, l.c. III. pl. LXXXI. fig. 442.

Locality.—Petane.

Genus OLIVA.

OLIVA NEOZELANICA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 314, pl. XVIII. fig. 1.

Shell oblong, the spire accuminate, of 4 or 5 whorls, each of which has an anterior callous band covering nearly half the whorl. Suture excavated. Aperture narrow, the columella twisted and with 4 or 5 spiral grooves anteriorly Length 37mm.; breadth 15mm.

Locality.—Patea.

Genus ANCILLARIA.

ANCILLARIA AUSTRALIS, Sowb. Sp. Conch. 1830, pl. VII. figs. 44-46; Tryon, l.c. V. pl. XXXVIII. figs. 28-29.

Locality.—Wanganui, Petane, Matapiro, Patea.

ANCILLARIA LATA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 325.

(Plate VI. fig. 15.)

Shell broad, tapering anteriorly, the spire short, all but the embryonic whorl covered by a large callus, which also extends over the posterior portion of the body whorl. Length up to 42mm.; breadth to 23mm.

Locality.—Wanganui, Petane.

Genus COLUMBELLA.

1. Shell without sculpture ... . *C. choava.*
2. Shell with spiral sculpture only.
   Aperture much less than half the length... ... *C. varians.*
   ,, about one-half the length ... ... *C. angustata.*
3. Shell with spiral and longitudinal sculpture.
   Spirals on penultimate whorl 7 or 8 ... ... *C. pisaniopsis.*
   ,, ,, ,, 5 ... ... *C. cancellaria.*

COLUMBELLA VARIANS, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 314, pl. XVIII. fig. 2.

(Plate VI. fig. 16.)

Shell oblong, the spire prominent and acute. Whorls 7, flattened, spirally grooved. Grooves variable, sometimes only one on the anterior half of the

whorl, sometimes several are equally distributed all over; generally there is a smooth band without grooves on each whorl; sometimes the spire whorls are quite smooth or with one or two grooves only. Suture deep. Aperture less than half the length of the shell, oval, with the right lip flattened; the posterior canal well marked; columella smooth and rounded; the anterior canal very short; right lip toothed within. Length 10mm.; breadth 4mm.

Locality.—Wanganui, Petane.

COLUMBELLA CHOAVA, Reeve, Conch. Icon. fig. 239; Tryon, l.c. V. pl. LI. fig. 51.

Locality.—Wanganui, Petane.

COLUMBELLA ANGUSTATA, Hutton, Trans. N.Z. Inst. Vol. XVIII. p. 333.

Shell elongate fusiform, spirally grooved, the spire longer than the aperture. Whorls 6-7, flattened, the suture distinct; spiral grooves narrow and rather distant, 7 on the penultimate and about 15 on the body whorl. Aperture elongately oval, not contracted in the middle. Length 11mm.; breadth 4mm.

Locality.—Petane.

COLUMBELLA PISANIOPSIS, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 314.

(Plate VI. fig. 17.)

Shell fusiform, the spire produced and sharp. Whorls 7; the two first embryonic, smooth, polished; the others rounded, rather gibbous behind, and with rather close spiral ribs. Spire whorls and posterior portion of the body whorl with regular, but not strong, longitudinal plications. There are 18 or 20 longitudinal plicæ on a whorl. The penultimate whorl has 7 or 8 spiral ribs, the body whorl has from 16 to 20. Suture well marked. Aperture narrow, roundly angled behind; the right lip sharp, toothed inside; the columella smooth. Length 10mm.; breadth 4mm.

Locality.—Petane, Matapiro.

COLUMBELLA CANCELLARIA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 314.

(Plate VI. fig. 18.)

Shell fusiform, the spire produced and sharp. Whorls 6 or 7, the first two embryonic, polished; the others slightly rounded and with strong spiral ribs crossed by longitudinal ribs, which are not so strong as the spiral ones, dividing the surface into squares. There are 5 spiral ribs on the penultimate whorl and

about 15 on the body whorl; the grooves are rather broader than the ribs and are longitudinally striated. The longitudinal ribs die away anteriorly on the body whorl. Suture well marked. Aperture narrow; the outer lip sharp, but thickened and toothed inside; the columella smooth. Length 13mm.; breadth 5mm.

Locality.—Wanganui, Petane.

Genus MARGINELLA.

MARGINELLA ATTENUATA, Reeve, Conch. Icon. fig. 116; Tryon, l.c. V. pl. .

Locality.—Petane.

Genus VOLUTA.

VOLUTA PACIFICA, Solander, Quoy and Gaimard, Voy. Astrolabe, Zool. II. p. 625, pl. XLIV. fig. 6; Tryon, l.c. IV. pl. XXVIII. fig. 97.

Locality.—Wanganui, Petane, Matapiro, Patea.

Variety ELONGATA, Swainson, Ex. Conch. pls. XX.-XXI.

Locality.—Wanganui.

VOLUTA GRACILIS, Swainson, Ex. Conch. pl. XLII.; Tryon, l.c. IV. pl. XXVIII. fig. 99.

Locality.—Wanganui, Petane, Matapiro.

Genus TURRICULA.

1. Spirally striated.
   14 longitudinals in a whorl ... ... *T. marginata.*
   12 or 13 longitudinals in a whorl ... ... *T. planata.*
2. No spiral striations.
   14 longitudinal plaits in a whorl ... ... *T. rubiginosa.*
   Numerous small nodules on spire whorls... ... *T. lincta.*

TURRICULA RUBIGINOSA, Hutton, Cat. Marine Moll. of N.Z. p. 20 (*Mitra*).

(Plate VI. fig. 19.)

Shell ovato-conical, smooth, the whorls longitudinally plicated, the plications getting obsolete on the body whorl, about 14 on a whorl; spire acute; aperture rather broad; columella with four oblique plaits. Length 8mm.; breadth 4mm.

Locality.—Wanganui, Petane.

TURRICULA MARGINATA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 315, pl. XVIII. fig. 4.

Shell ovato-conical, the spire acute, longer than the body whorl. Whorls with about 14 longitudinal ribs, which become obsolete on the body whorl, crossed by fine spiral striæ. Suture margined. Aperture narrow, contracted in front; the columella with four plaits. Length 8 mm.; breadth 2mm.

Locality.—Wanganui.

TURRICULA PLANATA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 315, pl. XVIII. fig. 3.

Shell ovato-fusiform, the spire acute, but not so long as the body whorl. Whorls flattened, distantly longitudinally ribbed and obscurely spirally striated. About 12 or 13 ribs on a whorl. Aperture narrow, the right lip not thickened; columella with four plaits. Length 14mm.; breadth 6mm.

Locality.—Wanganui.

TURRICULA LINCTA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 326.

Shell minute ovato-fusiform, smooth and shining. Whorls angled, those on the spire with numerous small longitudinal nodules, which gradually disappear on the body whorl. Suture covered. Body whorl spirally striated at the anterior end. Columella with four plaits, the anterior one very small. Length 5mm.

Locality.—Petane.

Genus TEREBRA.

Key to the species.

Longitudinal ribs 17 or 18 on a whorl	*T. tristis.*
,, ,, 11 to 15 ,, ...	*T. costata.*

TEREBRA TRISTIS, Deshayes, Pro. Zool. Soc. 1859, p. 306; Tryon, l.c. VII. pl. x. fig. 100.

Locality.—Wanganui, Petane, Matapiro, Patea.

TEREBRA COSTATA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 315, pl. XVIII. fig. 5.

(Plate VI. fig. 20.)

Shell smooth, polished, rather thick. Whorls 10-12, the first 2½ embryonic; the others longitudinally ribbed, about 11-15 ribs on a whorl, suture well marked. No posterior band on the whorls. Aperture ovate, the columella twisted, produced into a short, nearly straight canal. No posterior sinus. Length 13mm.; breadth 4mm.

Locality.—Wanganui.

Genus PLEUROTOMA.

Key to species.

A. No callus in aperture.

1. Whorls not spirally ornamented.

Whorls sharply keeled... ... ... *P. pagoda.*

2. Whorls spirally ribbed.

a. No longitudinal ribs or nodules.

α. Whorls keeled.

Spirals below the keel 15 ... ... *P. albula.*

„ „ „ 5 to 7 .... *P. nexilis.*

β. Whorls not keeled.

Spirals below the sinus 11-12 ... *P. cheesemani.*

b. Longitudinally ribbed.

α. Suture not margined. Longitudinal ribs 15 to 20 ... ... *P. protensa.*

β. Suture slightly margined.

Longitudinal ribs 11 to 15 ... *P. buchanani.*

„ „ 16 to 17 ... *P. plicatella.*

γ. Suture strongly margined.

Longitudinal ribs 13 to 16 ... *P. wanganuiensis.*

c. Shoulder with a row of nodules.

Spirals below the shoulder 7 ... *P. tuberculata.*

B. A posterior callus in the aperture *(Drillia).*

Spiral striation distinct ... ... *P. æquistriata.*

„ „ faint ... ... *P. alabaster.*

„ „ absent ... ... *P. lævis.*

PLEUROTOMA PAGODA, Hutton, Cat. Tertiary Moll. of N.Z. p. 5.

(Plate VI. fig. 21.)

Shell elongato-fusiform. Whorls smooth, strongly keeled. Below the keel a concavity bordered by a low spiral rib. Aperture ovate, contracted anteriorly; canal long, straight, narrow. Length 18mm.; breadth 6mm.

Locality.—Petane, Matapiro.

PLEUROTOMA ALBULA, Hutton, Cat. Marine Moll. of N.Z. p. 12; *P. antipodum*, E. A. Smith, Ann. and Mag. of Nat. Hist. 1877, Vol. XIX. p. 491.

(Plate VI. fig. 22.)

Shell small, fusiform. Whorls spirally grooved and with a central prominent spiral rib. Aperture oblong, contracted below; canal short, recurved. Length 10mm.; breadth 4mm.

Locality.—Petane, Matapiro.

PLEUROTOMA NEXILIS, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 317, pl. XVIII. fig. 9.

(Plate VI. fig. 23.)

Shell minute, fusiform, cancellated. Whorls 6, the two first embryonic, the others angled. Those of the spire with a prominent spiral keel crossed by rather oblique spiral threads forming an obtuse angle on the keel. Suture margined. Body whorl with 8 or 9 spiral ribs, the first and third larger than the others; all, after the sixth, very close together on the canal; these are crossed by rather distant longitudinal lines which form a very obtuse angle on the first spiral rib or keel. Aperture less than half the length of the shell, rather constricted and angled behind; columella straight, produced into a short canal. Length 4mm.

Locality.—Wanganui, Petane.

PLEUROTOMA CHEESEMANI, Hutton, Jour. de Conch. 1878, p. 16; *P. zealandica*, Smith, Ann. and Mag. Nat. Hist. 1877, Vol. XIX. p. 492 (not of Reeve).

(Plate VI. fig. 24.)

Shell ovato-fusiform, the spire gradated. Spire whorls smooth in front, obliquely striated behind. Body whorl as long as the spire, contracted towards the base; a smooth band at the sinus behind which it is obliquely striated and in front spirally ribbed, the interstices finely longitudinally striated; 9 or 10 ribs on the outer lip in front of the smooth band. Canal short, recurved. Length 20mm.; breadth 9mm.

Locality.—Wanganui, Petane.

PLEUROTOMA PROTENSA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 317 (*Daphnella*).

(Plate VI. fig. 25.)

Shell small, elongato-fusiform, with the spire longer than the body whorl. Whorls ornamented with delicate spiral threads crossed by growth lines, those of

the spire longitudinally ribbed; 15 to 20 ribs in a whorl. Suture well marked, not margined. Aperture oval, the canal short and broad; sinus small. Length 9mm.; breadth 3mm.

Locality.—Petane.

PLEUROTOMA BUCHANANI, Hutton, Cat. Tertiary Moll. of N.Z. p. 4.

(Plate VI. fig. 26.)

Shell elongato-fusiform. Whorls obliquely longitudinally plaited, and with fine spiral ribs below the sinus area; above the sinus area smooth, concave, with a slight ridge at the suture. Between 11 and 15 longitudinal plications on a whorl. Aperture oval, canal produced, rather bent. Length 22mm.; breadth 7mm.

Locality.—Wanganui, Petane, Matapiro.

PLEUROTOMA PLICATELLA, Hutton, Trans. N.Z. Inst. Vol. XVIII. p. 333.

(Plate VI. fig. 27.)

Shell fusiform. Whorls spirally striated, and longitudinally ribbed below the sinus area, and slightly so at the suture; about 15 to 17 in a whorl. On the body whorl the longitudinal ribs are obsolete except at the suture; the spiral ribs are irregular. Aperture oval with a short canal; the sinus deep. Length 24mm.; breadth 10mm.

Locality.—Wanganui.

PLEUROTOMA WANGANUIENSIS, Hutton, Cat. Tertiary Moll. of N.Z. p. 4.

(Plate VI. fig. 28.)

Shell fusiform, the spire longer than the body whorl. Whorls strongly spirally ribbed, and obliquely longitudinally ribbed in the centre. From 13 to 16 longitudinal ribs in a whorl. Suture very finely obliquely striated, and with a spiral rib. Aperture oval, canal short and recurved. Length 14mm.; breadth 5mm.

Locality.—Wanganui, Petane, Matapiro.

PLEUROTOMA TUBERCULATA, Kirk, Trans. N.Z. Inst. Vol. XIV. p. 409.

(Plate VI. fig. 29.)

Shell fusiform, the spire equal to the body whorl. Whorls keeled, strongly spirally ribbed, and with a row of tubercles on the keel; the suture plicated.

Sinus area with fine spiral lines; the spiral ribs on the body whorl, below the tubercles, are more distant. Aperture oval; canal moderate, twisted. Length 22mm.; breadth 8mm.

Locality.—Petane.

PLEUROTOMA ÆQUISTRIATA, Hutton, Trans. N.Z. Inst. Vol. XVIII. p. 334.

(Plate VII. fig. 30.)

Shell fusiform, the spire longer than the body whorl. Whorls spirally striated and longitudinally ribbed; there are 15 longitudinal ribs on a whorl. Sinus area concave and covering the suture, spirally striated. Aperture oval, canal very short; inner lip with a large posterior callus. Length 18mm.; breadth 5mm.

Locality.—Petane.

PLEUROTOMA ALABASTER, Reeve, Pro. Zool. Soc. 1843, p. 181.

(Plate VII. fig. 31.)

Shell fusiform, the spire much longer than the body whorl. Whorls with very fine spiral striations and oblique longitudinal, slight plications on the spire whorls; there are about 16 or 17 plications on a whorl. Sinus area nearly smooth. Aperture oval, the canal short and straight; sinus rather deep. Length 15mm.; breadth 5mm.

The callus in the aperture is sometimes absent.

Locality.—Wanganui, Matapiro.

PLEUROTOMA LÆVIS, Hutton, Cat. Marine Moll. of N.Z. p. 12.

(Plate VII. fig. 32.)

Shell fusiform, the spire longer than the body whorl. Whorls smooth with longitudinal plications; about 14 on a whorl. Aperture oval, canal short and straight; sinus deep. Length 18mm.; breadth 7mm.

Locality.—Wanganui, Petane.

Genus DAPHNELLA.

Key to the species.

Surface finely cancellated ... ... *D. lymnæiformis.*
,, finely spirally striated ... . *D. striata.*
,, spirally ribbed; minute ... ... *D. lacunosa.*

DAPHNELLA LYMNÆIFORMIS, Kiener, Icon. Pleurotoma, p. 62; Tryon, l.c. Vol. VI. pl. xxv. fig. 60.

Locality.—Wanganui.

DAPHNELLA STRIATA, Hutton, Cat. Tertiary Moll. of N.Z. p. 5 (*Bela*).

(Plate VII. fig. 33.)

Shell fusiform, the spire rather shorter than the body whorl. Whorls 6-7 finely spirally striated. Aperture oblong, canal short, slightly recurved; the right lip thickened; sinus obsolete. Length 24mm.; breadth 9mm.

Locality.—Wanganui, Petane.

DAPHNELLA LACUNOSA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 317.

(Plate VII. fig. 34.)

Shell minute, fusiform. Whorls 5, the first two embryonic, the others with strong spiral ribs at equal distances. Spire whorls with 3, body whorl with 10 or 12 of these ribs; the grooves rather broader than the ribs and smooth. Aperture ovate, about half the length of the shell; the sinus obsolete; canal short, outer lip thin. Length 5mm.

Locality.—Wanganui.

Genus CLATHURELLA.

Key to the species.

Between 12 and 15 longitudinal ribs in a whorl	...	*C. hamiltoni.*
About 11 longitudinal ribs in a whorl.		
Whorls cancellated into squares ...	...	*C. dictyota.*
Whorls not cancellated, spiral striæ slight	...	*C. sinclairii.*
" " " spiral striæ strong	...	*C. abnormis.*

CLATHURELLA HAMILTONI, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 316, pl. XVIII. fig. 7.

(Plate VII. fig. 35.)

Shell ovato-fusiform. Whorls strongly longitudinally ribbed and with fine spiral threads. About 12-15 longitudinal ribs in a whorl. Aperture ovate, rather angled behind; sinus obsolete; the anterior end deeply notched, and the inner lip reflected over the columella. Length 16mm.; breadth 9mm.

Locality.—Wanganui, Petane, Matapiro.

CLATHURELLA SINCLAIRII, Smith, Ann. and Mag. Nat. Hist. 1884, Vol. XIV. p. 320.

Locality.—Wanganui, Petane.

CLATHURELLA ABNORMIS, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 316.

(Plate VII. fig. 36.)

Shell minute mitri-form, the spire produced and acute. Whorls angled, strongly longitudinally costate and spirally lined. There are 11 longitudinal ribs on a whorl, which are crossed by three or four spiral threads in front of the angle, none behind it. On the body whorl the spiral threads in front of the angle are about 12. Aperture narrow, with a well marked sinus. Length 5 mm.; breadth 2 mm.

Locality.—Petane.

CLATHURELLA (?) DICTYOTA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 316, pl. XVIII. fig. 8.

(Plate VII. fig. 37.)

Shell minute, elongato-fusiform, the whorls slightly angled and cancellated. Longitudinal ribs narrow and distant, about 11 in a whorl. Spire whorls with three strong distant spiral ribs, the interstices finely spirally striated; body whorl with about nine spiral ribs, the posterior three larger and alternating with a small rib as well as the spiral striæ. Aperture oval, nearly half the length of the shell; posterior sinus broad and shallow; anterior canal moderate. Length 6 mm.; breadth 3 mm.

Locality.—Wanganui, Petane.

Genus TRITON.

TRITON SPENGLERI, Lamarck; Tryon, l.c. III. p. 16, pl. IX. fig. 61.

Locality.—Wanganui.

Genus CASSIS.

CASSIS PYRUM, Lamarck; Tryon l.c.

Locality.—Wanganui.

Genus NATICA.

Key to the species.

1. Shell orbicular, umbilicus open.
   - A funiculus, umbilicus rather wide ... ... *N. neozelanica.*
   - No funiculus, callus small ... ... *N. australis.*
2. Shell orbicular, umbilicus closed by a callus.
   - Callus thin... ... ... *N. lævis.*
   - Callus thick, extended posteriorly ... ... *N. gibbosa.*
3. Shell oval, solid, with a large callus (*Mamma*).
   - Umbilicus not covered ... ... *N. ovata.*

NATICA NEOZELANICA, Quoy and Gaimard, Voy. Astrolabe, Zool. II. p. 237, pl. LXVI. figs. 11, 12.

Locality.—Wanganui, Petane, Matapiro, Patea.

NATICA AUSTRALIS, Hutton, Jour. de Conch. 1878, p. 23 (*Lunatia*).

(Plate VII. fig. 38.)

Shell globose and smooth. Whorls $3\frac{1}{2}$, the suture well marked but not excavated. Umbilicus narrow without any funiculus; a small posterior callus in the aperture. Length 7 mm.; breadth 7 mm.

Locality.—Wanganui, Petane, Matapiro.

NATICA LÆVIS, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 317.

(Plate VII. fig. 39.)

Shell sub-globose, transverse, smooth, without any spiral markings. Whorls 4, the two first polished. Aperture broadly ovate, rounded in front; columella curved, the callus covering the umbilicus. Length 19 mm.; breadth 23 mm.

Locality.—Wanganui, Petane.

NATICA GIBBOSA, Hutton, Trans. N.Z. Inst. Vol. XVIII. p. 334.

Shell large, solid, smooth, gibbous, the spire almost buried; the body whorl gibbous posteriorly. Aperture semicircular, the columellar callus very large, filling the posterior portion of the aperture, and eventually covering the whole umbilical region. Length 50 mm.; breadth 50 mm.

Locality.—Matapiro. A single specimen only.

NATICA OVATA, Hutton, Cat. Tertiary Moll. of N.Z. p. 9.

(Plate VII. fig. 40.)

Shell pyriformly ovate, smooth, thick. Whorls 5 or 6, the suture covered. Aperture semi-lunar; columellar callus large, but never completely covering the umbilicus. Length 37mm.; breadth 31mm.

Locality.—Wanganui, Patea. Rare.

Genus SIGARETUS.

Key to the species.

Umbilicus covered	... ...	*S. undulatus.*
„ exposed *(Naticina)*	... ...	*S. cinctus.*

SIGARETUS UNDULATUS, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 318.

(Plate VII. fig. 41.)

Shell sub-globose, smooth, ornamented with delicate, close undulating spiral lines. Whorls $4\frac{1}{2}$, the first $2\frac{1}{2}$ polished. Aperture ovate, rather produced anteriorly; columella curved, the callus completely covering up the umbilicus. Length 21mm.; breadth 21mm.

Locality.—Wanganui, Petane.

SIGARETUS CINCTUS, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 318.

Shell globoso-ovate, smooth, closely spirally grooved, the grooves shallow. Whorls $4\frac{1}{2}$, the first three without spiral markings. Suture excavated. Aperture oblong, the columella nearly straight; umbilicus widely open. Length 15mm.; breadth 14mm.

Locality.—Wanganui.

Genus EULIMA.

EULIMA TREADWELLI, Hutton; *E. micans*, Trans. N.Z. Inst. Vol. XVII. p. 318 (not of Tenison-Woods).

(Plate VII. fig. 42.)

Shell minute, subulate, highly polished, slightly curved to the right. Whorls 6, flattened, enamelled, suture almost obliterated. Aperture oval, rounded in front and pointed behind, the columella curved. Length 4mm.

Locality.—Wanganui.

EULIMA (?) MEDIA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 318.

(Plate VII. fig. 43.)

Shell minute, slightly polished, straight. Whorls 6 or 7, slightly convex, smooth, without any markings; suture impressed. Aperture ovate, rounded in front but not pointed behind; columella curved to the right, not umbilicated. Length 4mm.

Locality.—Wanganui.

Genus TURBONILLA.

TURBONILLA NEOZELANICA, Hutton, Cat. Marine Moll. of N.Z. p. 22 *(Chemnitzia)*.

(Plate VII. fig. 44.)

Shell small, turreted, smooth. Whorls 8, the first two embryonic, the others longitudinally plaited. Aperture ovate, the peristome incomplete Length 6mm.

Locality.—Wanganui, Petane.

Genus EULIMELLA.

EULIMELLA DEPLEXA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 318.

(Plate VII. fig. 45.)

Shell minute, slightly polished, straight. Whorls 6-7, flattened, smooth, without any markings; suture impressed. Aperture subquadrate; columella straight, callously reflected over the umbilical region. Length 4mm.

Locality.—Wanganui.

EULIMELLA OBLIQUA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 318.

(Plate VII. fig. 46.)

Shell minute, smooth, almost polished, slightly curved to the right. Whorls 7 or 8, the last slightly keeled in the middle; suture rather obscure. Aperture subquadrate, pointed behind; columella straight and parallel to the outer lip. Length 3mm.

Locality.—Petane.

Genus ACLIS.

ACLIS COSTELLATA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 319.

(Plate VII. fig. 47.)

Shell minute, subulate. Whorls 6, rounded, the first two smooth and polished, the rest spirally grooved. Whorls with the two posterior spiral grooves deeper and broader than the others, and the rib between them higher; crossed by delicate longitudinal plications; base of the body whorl very finely spirally grooved. Suture well marked. Aperture ovate, less than half the length of the shell; columella arched; umbilicus covered. Length 3mm.

Locality.—Wanganui.

Genus ODOSTOMIA.

Key to the species.

Whorls longitudinally plicated *(Parthenia)*	*O. rugata.*
Whorls spirally grooved *(Pyramis)*	*O. fasciata.*
Whorls not ornamented.	
Shell not polished	*O. lactea.*
,, polished, whorls 10	*O. georgiana.*
,, ,, ,, 15	*O. sheriffii.*

ODOSTOMIA LACTEA, Angas, Pro. Zool. Soc. 1867, p. 112, pl. XIII. fig. 11 (not of Linn.)

(Plate VII. fig. 48.)

Locality.—Wanganui, Petane, Matapiro.

ODOSTOMIA GEORGIANA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 319.

(Plate VII. fig. 49.)

Shell rather elongated, polished. Whorls 10, flattened, irregularly longitudinally marked, but not plicated; body whorl very obtusely keeled. Suture impressed. Aperture oval, pointed behind; columella with a single deep, posterior, oblique fold, nearly or quite covering the umbilicus. Length 15mm.

Locality.—Wanganui, Petane.

ODOSTOMIA SHERIFFII, Hutton, Trans. N.Z. Inst. Vol. XV. p. 411.

Shell much elongated, subulate. Whorls 15, smooth, flattened and polished, the suture deep. Aperture ovate, pointed behind; columella with one strong plait. Length 14mm.

Locality.—Wanganui.

ODOSTOMIA FASCIATA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 320.

(Plate VII. fig. 50.)

Shell minute, ovato-elongated. Whorls 5, the first rounded and polished, the rest flattened; those of the spire with three small spiral grooves at the posterior end, a broad smooth band in the centre and a single groove at the anterior end. Body whorl with numerous spiral grooves in front of the smooth band. Suture impressed. Aperture ovate; columella with a single nearly obsolete fold; umbilicus open. Length 4mm.

Locality.—Wanganui.

ODOSTOMIA RUGATA, Hutton; *O. plicata*, Trans. N.Z. Inst. Vol. XVII. p. 319 (not of Montfort).

(Plate VII. fig. 51.)

Shell minute, ovato-elongated, longitudinally plicated. Whorls 6, flattened, irregularly longitudinally plicated on the posterior half only, the anterior half of the body whorl smooth; the whole shell faintly spirally striated. Suture impressed. Aperture ovate; columella with a single rather strong fold; the umbilicus covered. Length 3mm.

Locality.—Wanganui, Petane.

Genus TRIVIA.

TRIVIA NEOZELANICA, Kirk, Trans. N.Z. Inst. Vol. XIV. p. 409.

Locality.—Petane, Matapiro.

Genus CANCELLARIA.

CANCELLARIA TRAILLI, Hutton, Cat. Marine Moll. of N.Z. p. 26.

(Plate VII. fig. 52.)

Shell small, thin, oval; spire short, the whorls angled. The entire shell very finely cancellated. Columella with three oblique folds; outer lip slightly crenate. Length 6mm.; breadth 4mm.

Locality.—Wanganui, Petane.

CANCELLARIA LACUNOSA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 320.

(Plate VII. fig. 53.)

Shell ovato-fusiform. Whorls 6, the first two embryonic, the others rounded, spirally ribbed and longitudinally plicated. Spiral ribs three on the spire whorls and seven or eight on the body whorl, with fine spiral threads between them. Longitudinals numerous and rather oblique, about 15 in a whorl. Aperture broadly ovate; columella with three strong folds; no anterior notch; outer lip acute. Length 11mm.; breadth 9mm.

Locality.—Petane.

Genus ADMETE.

ADMETE (?) AMBIGUA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 320.

(Plate VII. fig. 54.)

Shell minute, ovate, perforated, spirally striated. Whorls 4, the first two smooth, the others rather convex, spirally grooved, about 18 or 20 grooves on the body whorl. Suture well marked. Aperture ovate, more than half the length of the shell; columella smooth, rather produced in front, not covering the umbilicus. Length 2mm.

Locality.—Wanganui.

Genus TRICHOTROPIS.

TRICHOTROPIS INORNATA, Hutton, Cat. Marine Moll. of N.Z. p. 26; *T. clathrata*, Sowb. in Reeve, Conch. Icon. fig. 10; Voy. Erebus and Terror, Moll. pl. I. fig. 21.

Locality.—Wanganui, Petane, Matapiro.

Genus CERITHIUM.

CERITHIUM CANCELLATUM, Hutton, Cat. Tertiary Moll. of N.Z. p. 12.

(Plate VII. fig. 55.)

Shell small, turreted; the whorls cancellated. Whorls 9, the first smooth, the two next with longitudinal ribs, the rest with longitudinal and spiral ribs. Longitudinals about 23 in the penultimate whorl. Spirals five in the spire whorls and 13 or 14 on the body whorl; the longitudinals on the body whorl not continued on to the base. Suture deep. Aperture broadly ovate, suddenly contracted into the twisted canal; inner lip reflected. Length 14mm.; breadth 6mm.

Locality.—Wanganui, Petane.

Genus BITTIUM.

BITTIUM TEREBELLOIDES, Martens, Critical list of N.Z. Moll. p. 26.

(Plate VII. fig. 56.)

Shell turreted; on the upper whorls three, on the last four spiral ribs of nearly equal size, the interstices faintly longitudinally striated. Aperture deeply notched. Length 8 mm.

Locality.—Wanganui, Petane.

BITTIUM CINCTUM, Hutton, Trans. N.Z. Inst. Vol. XVIII. p. 334.

(Plate VII. fig. 57.)

Shell turreted; on the upper whorls four, on the last 6-8 spiral ribs of nearly equal size. Length, 14 mm.

Locality.—Wanganui, Petane.

Genus CERITHIDEA.

CERITHIDEA BICARINATA, Gray in Dieffenbach's "New Zealand," Vol. II. p. 241; Voy. Erebus and Terror, Moll. pl. I. fig. 20.

Locality.—Wanganui, Petane, Matapiro.

Genus STRUTHIOLARIA.

Key to the species.

1. Whorls spirally striated.
   - About 14-15 tubercles on a whorl ... ... *S. papulosa.*
   - Subnodulose, whorls flattened ... ... *S. vermis.*
2. Whorls deeply spirally grooved.
   - Body whorl with 10 spirals ... ... *S. fraseri.*
   - " " 13-14 spirals ... ... *S. cingulata.*

STRUTHIOLARIA PAPULOSA, Martyn, Univ. Conch. pl. LIV; *S. straminea*, Woodward, Manual of the Mollusca, pl. IV. fig. 6.

Locality.—Wanganui.

Struthiolaria fraseri, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 329; Hector, Outlines of Geol. of N.Z. p. 14, fig. 1.

Shell spirally grooved. Whorls keeled and flattened, gradated; usually a row of small tubercles on the keel. Spire whorls with 3-4 grooves behind the keel and 4-5 in front of it. Body whorl with about 10 spiral grooves in front of the keel. Length 77mm.; breadth 46mm.

Locality.—Matapiro.

Struthiolaria vermis, Martyn, Univ. Conch. pl. liii; *S. crenulata,* Quoy and Gaimard, Voy. Astrolabe, Zool. II. p. 430, pl. xxxi. figs. 7-9.

Locality.—Wanganui, Petane, Matapiro.

Struthiolaria cingulata, Zittel, Reise der Novara, Palæontologie, p. 35, taf. xv. fig. 2

Locality.—Patea. A single specimen only.

Genus CALYPTRÆA.

Key to the species.

1. Apex lateral.
   - Shell flattened ... ... *C. calyptræformis.*
   - Shell inflated ... ... *C. inflata.*
2. Apex sub-central.
   - Shell flattened ... ... *C. scutum.*
   - Shell conical ... ... *C. alta.*

Calyptræa calyptræformis, Linn.; *Crepidula maculata,* Quoy and Gaimard, Voy. Astrolabe, Zool. III. p. 422, pl. lxxii. figs. 6-9.

Locality.—Wanganui, Petane, Matapiro.

Calyptræa inflata, Hutton, Trans. N.Z. Inst. Vol. XV. p. 411.

(Plate vii. fig. 58.)

Shell sub-globose. Whorls $2\frac{1}{2}$, rounded, the last inflated, with 4-5 distant, low, spiral ribs crossed obliquely by lines of growth. Apex lateral. Length of aperture 20mm.; breadth 18mm.; height of shell 10mm.

Locality.—Wanganui.

CALYPTRÆA SCUTUM, Lesson, Voy. Coquille, Zool. II. p. 1830.

Locality.—Wanganui, Petane, Matapiro.

CALYPTRÆA ALTA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 329.

(Plate VII. fig. 59.)

Shell subcircular, conical, high. Apex subcentral. Height 16mm.; diameter 25mm.

Locality.—Petane, Matapiro.

Genus CREPIDULA.

CREPIDULA ACULEATA, Gml.; *C. costata*, Quoy and Gaimard, Voy. Astrolabe, Zool. III. p. 414, pl. LXXII. figs. 10-11.

Locality.—Wanganui, Petane, Matapiro.

CREPIDULA MONOXYLA, Lesson, Voy. Coquille, Zool. II. p. 391; *C. contorta*, Quoy and Gaim. l.c. III. p. 418, pl. LXXII. figs. 15-16; *C. profunda*, Hutton, Cat. Tertiary Moll. of N.Z. p. 14.

Locality.—Wanganui, Petane, Matapiro.

CREPIDULA UNGUIFORMIS, Lamarck, Reeve, Conch. Icon. fig. 1.

Locality.—Wanganui, Petane.

Genus HIPPONYX.

HIPPONYX UNCINATUS, Hutton, Cat. Tertiary Moll. of N.Z. p. 14 *(Pilæopsis)*.

Shell irregularly conical; apex anterior, recurved, uncinate, subspiral. Whorls 1, smooth, with fine radiating lines in places; aperture large, irregularly orbicular. Height 20mm.; diameter 27mm.

Locality.—Wanganui.

Genus TURRITELLA.

Key to the species.

One central spiral rib	*T. pagoda.*
Two strong spiral ribs on each whorl	*T. bicincta.*
Three strong spiral ribs on each whorl	*T. tricincta.*
Spiral ribs increasing from 2 to 6 on a whorl	*T. rosea.*

TURRITELLA ROSEA, Quoy and Gaimard, Voy. Astrolabe, Zool. III. p. 136, pl. LV. figs. 24-26.

Locality.—Wanganui, Petane, Matapiro.

TURRITELLA TRICINCTA, Hutton, Cat. Tertiary Moll. of N.Z. p. 13.

(Plate VIII. fig. 60.)

Whorls with three sub-equal and equidistant strong spiral ribs, the interstices finely spirally striated. Length 30mm.

Locality.—Wanganui, Petane, Matapiro.

TURRITELLA BICINCTA, Hutton, Cat. Tertiary Moll. of N.Z. p. 13.

(Plate VIII. fig. 61.)

Whorls with two strong spiral ribs, the anterior of which is usually the larger, and sometimes moniliform. The interstices finely spirally striated. Length 25 mm.

Locality.—Petane, Matapiro.

TURRITELLA PAGODA, Reeve, Conch. Icon. fig. 60.

Locality.—Wanganui.

Genus EGLISIA.

EGLISIA PLANOSTOMA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 320.

(Plate VIII. fig. 62.)

Shell minute, turreted. Whorls 8 or 9, flattened, the anterior portion concave, smooth. Spire whorls with four strong equal spiral ribs, body whorl

with 5 or 6 spiral ribs and a smooth base. Suture well marked. Aperture ovate, flattened anteriorly, and the outer lip rather straight. Length 5 mm.

Locality.—Wanganui, Petane.

Genus RISSOA.

Key to the species.

1. Spire whorls longitudinally ribbed.	
Body whorl smooth	*R. rugulosa.*
,, ,, with one spiral groove	*R. impressa.*
,, ,, with several spiral grooves.	
Whorls 5	*R. gradata.*
,, 6 or 7	*R. rugosa.*
2. Spire whorls not longitudinally ribbed.	
Whorls smooth, not polished	*R. annulata.*
,, finely spirally striated	*R. emarginata.*
Body whorl spirally grooved, spire whorls smooth	*R. semisulcata.*

RISSOA RUGULOSA, Hutton, Cat. Marine Moll. of N.Z. p. 28.

(Plate VIII. fig. 63.)

Whorls 7, smooth, obscurely longitudinally ribbed, aperture ovate, pointed behind, peritreme continuous. Length 8 mm.

Locality.—Petane.

RISSOA IMPRESSA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 321.

(Plate VIII. fig. 64.)

Shell pupiform. Whorls 5, the two first smooth, the others longitudinally plicated; base of the body whorl smooth; a single spiral groove just below the suture, which is margined. Aperture broadly ovate; peritreme continuous and rather patulous. Length 2mm.

Locality.—Petane.

RISSOA GRADATA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 321.

(Plate VIII. fig. 65.)

Shell small, ovate, cancellated. Whorls 5, gradated; the two first smooth and polished; the others longitudinally and spirally ribbed. Longitudinals about

15 in a whorl. Spirals—a posterior one near the angle and two anterior ones with a smooth band between them. On the body whorl about 7 spirals in front of the smooth band, and the longitudinals become obsolete. Suture impressed. Aperture roundly ovate, peritreme continuous. Length 3mm.

Locality.—Wanganui, Petane.

RISSOA RUGOSA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 321.

(Plate VIII. fig. 66.)

Shell robust, pupiform, roughish. Whorls 6 or 7, the first $1\frac{1}{2}$ polished, the others of the spire longitudinally plicated, with one spiral rib and a sulcus behind, and two in front of the plications; plications more or less nodulose. Body whorl sometimes not longitudinally plicated, the posterior half with about 8 spiral ribs, the anterior half smooth. Aperture broadly ovate, the peritreme continuous and rather patulous. Length 4mm.

Locality.—Petane.

RISSOA ANNULATA, Hutton, N.Z. Journal of Science, Vol. II. p. 173.

(Plate VIII. fig. 67.)

Shell minute, ovate, smooth. Whorls 5, slightly rounded, the suture well marked. Aperture rounded, the peritreme continuous in the adult. Length 2mm.

Locality.—Wanganui, Petane.

This is really a *Rissoina*, but, as the operculum is never preserved, it is better to consider it here as a species of *Rissoa*.

RISSOA EMARGINATA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 320.

(Plate VIII. fig. 68.)

Shell minute, ovato-conical, smooth, polished, very delicately spirally striated. Whorls 6, flattened, the two first very small and smooth. Suture obscure. Aperture ovate, the peritreme continuous; slightly notched anteriorly. Length 2mm.

Locality.—Wanganui, Petane.

RISSOA SEMISULCATA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 321.

(Plate VIII. fig. 69.)

Shell minute, pupiform, thick. Whorls 5, flattened; the first three or four smooth; the last, or the two last, smooth anteriorly, and with four shallow but well marked spiral grooves on the posterior half. Suture distinct. Aperture roundly ovate, not notched anteriorly, peritreme continuous. Length 3mm.

Locality.—Wanganui.

Genus RISELLA.

RISELLA MELANOSTOMA, Gml. in Linné's Syst. Nat. ed. 13, p. 3581, No. 90.

Locality.—Wanganui.

Genus VERMETUS.

VERMETUS NEOZELANICA, Quoy and Gaim. Voy. Astrolabe, Zool. Vol. III. p. 393, pl. LXVII. figs. 16-17.

Locality.—Wanganui.

VERMETUS MONILIFERUS, Hutton, Cat. Tertiary Moll. of N.Z. p. 13 (*Cladopoda*).

(Plate VIII. fig. 70.)

Shell irregularly twisted; rugose, with unequal longitudinal moniliform ribs, crossed by numerous transverse growth marks. Transverse section subcircular.

Locality.—Wanganui.

Genus SCALARIA.

Key to the species.

Longitudinal ribs 11 to 13 in a whorl	*S. zelebori.*
,, ,, 18 to 20 ,, ...	*S. nympha.*
,, ,, 22 to 24 ,, ...	*S. corulum.*

SCALARIA ZELEBORI, Frauenfeld, Reise der Novara, Moll. pl. I. fig. 6; *S. intermedia*, Hutton, Cat. Tertiary Moll. p. 10.

Locality.—Wanganui, Petane.

SCALARIA NYMPHA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 321.

(Plate VIII. fig. 71.)

Shell small, turreted. Whorls slightly rounded, very finely spirally striated and longitudinally ribbed. About 18 or 20 ribs and two or three larger varices in each whorl. Suture impressed. Body whorl keeled anteriorly, all the longitudinal ribs ending at the keel; base slightly concave and smooth below the keel. Aperture sub-rotund. Length ?

Locality.—Petane.

SCALARIA CORULUM, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 322.

(Plate VIII. fig. 72.)

Shell minute, ovate, slightly perforated. Whorls 5, very convex, the two first smooth, the others longitudinally ribbed; about 22 to 24 ribs in a whorl, the interstices finely spirally lined. Suture deep; body whorl rounded. Aperture roundly ovate, peritreme continuous. Length 2mm.

Locality.—Wanganui.

Genus XENOPHORA.

XENOPHORA CONCHYLIOPHORA, Born; *Phorus agglutinans*, Lamarck, Anim. sans Vert. Vol. IX. p. 161.

Locality.—Petane.

Genus TURBO.

TURBO SMARAGDUS, Martyn, Univ. Conch. pl. LXXIII.-LXXIV.; Reeve, l.c. fig. 13.

Locality.—Napier.

TURBO GRANOSUS, Martyn, Univ. Conch. pl. XXXVII.; *T. rubicundus*, Reeve, fig. 11.

Locality.—Wanganui.

Genus IMPERATOR.

IMPERATOR IMPERIALIS, Chemnitz, Conch. Cab. V. pl. XIII.; Woodward, Manual of the Mollusca, pl. x. fig. 4.

Locality.—Wanganui.

Genus ROTELLA.

ROTELLA NEOZELANICA, Hombron and Jacquinot, Voy. Pôle Sud, Zool. V. p. 53, pl. XIV. figs. 5-6; *R. vestiaria*, Woodward, l.c. pl. x. fig. 10.

Locality.—Wanganui, Petane, Matapiro.

Genus TROCHUS.

Key to the species.

1. Columella twisted.
   - Four spirals on penultimate whorl ... ... *T. viridis.*
   - Seven or eight " " ... ... *T. conicus.*
2. Columella not twisted.
   - Spirals subequal above the keel ... ... *T. tiaratus.*
   - Spirals at keel and posterior margin larger ... *T. chathamensis.*

TROCHUS VIRIDIS, Gml.; *Polydonta tuberculata*, Gray, Voy. Erebus and Terror, Moll. pl. I. fig. 6.

Locality.—Wanganui.

TROCHUS CONICUS, Hutton, Trans. N.Z. Inst. Vol. XV. p. 411.

(Plate VIII. fig. 73.)

Shell high. Whorls 7, slightly convex, with fine spiral moniliform ribs, about 8 on the penultimate whorl. Suture deep. Base with spiral moniliform striæ, the angle rounded. Axial cavity deep, smooth, conical; columella with a posterior fold. Height 21mm.; breadth 21mm.

Locality.—Wanganui.

TROCHUS TIARATUS, Quoy and Gaimard, Voy. Astrolabe, Zool. III. p. 256, pl. LXIV. figs. 6-11.

Locality.—Wanganui, Petane, Matapiro.

TROCHUS CHATHAMENSIS, Hutton, Cat. Marine Moll. of N.Z. p. 36.

(Plate VIII. fig. 74.)

Whorls flat, with five or six sub-nodulose spiral ribs, those at the keel and at the posterior margin of the whorl larger than the others; the base spirally striated; axial cavity small, smooth. Height 8 mm.; breadth 9 mm.

Locality.—Wanganui.

Genus CALLIOSTOMA.

Key to the species.

1. Base with a large callus.
   Penultimate whorl with 10-11 equidistant spirals ... *C. cunninghami.*
   ,, ,, 7-8 spirals, the posterior 5 or 6 much closer ... ... *C. ponderosum.*
2. Base with a small callus.
   Penultimate whorl with 8-10 equidistant spirals *C. pellucidum.*
3. Base without any callus.
   Penultimate whorl with 4 or 5 spirals ... ... *C. hodgei.*
   ,, ,, 10 or 12 spirals ... *C. punctulatum.*

CALLIOSTOMA CUNNINGHAMI, Gray; Reeve, Conch. Icon. fig. 6.

Locality.—Wanganui.

CALLIOSTOMA PONDEROSUM, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 322.

(Plate VIII. fig. 75.)

Shell large, solid. Whorls 5 or 6, flattened, the periphery roundly angled; with 7 or 8 spiral ribs, the anterior two distant, the others much closer. Suture distinct. Base with about 12 fine spiral ribs. Aperture rhomboidal; the umbilical callus large. Height 35 mm.; breadth 43 mm.

Locality.—Wanganui.

CALLIOSTOMA PELLUCIDUM, Valenciennes, Voy. Venus, Moll. pl. IV. fig. 2.

Locality.—Wanganui, Petane.

CALLIOSTOMA HODGEI, Hutton, Trans. N.Z. Inst. Vol. VII. p. 458, pl. XXI.

Shell thin, the whorls flattened and suture obscure; outline of spire concave. Whorls sharply angled and with 5 spiral moniliform lines on the penultimate whorl. Base without any callosity, or a very small one. Height 21mm.; breadth 24mm.

Locality.—Wanganui, Petane.

CALLIOSTOMA PUNCTULATUM, Martyn, Univ. Conch. pl. XXXVII.; *Turbo diaphanus*, Quoy and Gaimard, l.c. pl. LXIV. figs. 1-5.

Locality.—Wanganui, Petane.

Genus CANTHARIDUS.

Key to the species.

Spirals on penultimate whorl, 8 to 12 ... ... *C. tenebrosus.*
Spirals on penultimate whorl, 5 or 6.
Shell depressed, spirals smooth ... ... *C. pupillus.*
Shell high, spirals moniliform ... ... *C. sanguineus.*

CANTHARIDUS TENEBROSUS, Adams, Pro. Zool. Soc. 1851, p. 170.

Locality.—Wanganui, Petane.

CANTHARIDUS PUPILLUS, Gould, United States Expl. Exp. XII. p. 186, Atlas, fig. 108.

Locality.—Wanganui, Petane.

CANTHARIDUS SANGUINEUS, Gray, in Dieffenbach's "New Zealand," II. p. 238; Voy. Erebus and Terror, Moll. pl. I. fig. 2.

Locality.—Wanganui, Petane.

Genus MONILEA.

MONILEA EGENA, Gould, l.c. p. 116, Atlas, fig. 228; *Margarita zealandica*, Reeve, Conch. Icon. fig. 17.

Locality.—Wanganui, Petane, Matapiro.

Genus MONODONTA.

Key to the species.

Whorls with distant spiral groove	... ...	*M. æthiops.*
,, smooth, or with smooth spiral ribs ...	...	*M. melanoloma.*
,, with three strong nodulose spiral ribs	...	*M. lugubris.*

MONODONTA ÆTHIOPS, Gmelin; *Trochus zealandicus*, Quoy and Gaimard, l.c. III. p. 257, pl. LXIV. figs. 12-15.

Locality.—Wanganui.

MONODONTA MELANOLOMA, Menke, Moll. Novæ Hollandiæ, No. 50, p. 14.

Locality.—Wanganui.

MONODONTA LUGUBRIS, Gmel.; *Trochus cingulatus*, Quoy and Gaimard, l.c. III. p. 259, pl. LXIV. figs. 16-20.

Locality.—Wanganui.

Genus CYCLOSTREMA.

CYCLOSTREMA OBLIQUATA, Hutton, Trans. N.Z. Inst. Vol. XVIII. p. 335.

Shell large, spiral, depressed, smooth (?), with a spiral groove above the periphery. Whorls 4, increasing rather rapidly. Suture deep. Umbilicus wide. Aperture oval, very oblique; peristome continuous, sharp. Greatest diameter 20mm.; least diameter 16mm.; height 16mm.

Locality.—Wanganui. A single specimen.

Genus SCISSURELLA.

SCISSURELLA MANTELLI, Woodward, Pro. Zool. Soc. 1859, p. 202, pl. XLVI.; Tryon, l.c. XII. pl. LVII. fig. 12.

Locality.—Petane.

Genus HALIOTIS.

HALIOTIS RUGOSO-PLICATA, Chemnitz, Reeve, Conch. Icon. fig. 7; Tryon, l.c. XII. pl. xx. figs. 12, 13.

Locality.—Matapiro.

Genus MEGATEBENNUS.

MEGATEBENNUS MONILIFERUS, Hutton, Cat. Marine Moll. of N.Z. p. 42 *(Lucapina).*

(Plate VIII. fig. 76.)

Shell ovate, cancellated, the radiating striæ submoniliform. Perforation large, subcentral, contracted at the sides, bordered internally by a callus. Length 15 mm.

Locality.—Wanganui, Petane.

Genus EMARGINULA.

EMARGINULA STRIATULA, Quoy and Gaimard, Voy. Astrolabe, Zool. III. p. 332, pl. LXVIII. figs. 21, 22; Tryon, l.c. XII. p. 259, pl. LXIV. fig. 2.

Locality.—Wanganui, Petane.

Genus SUBEMARGINULA.

SUBEMARGINULA PARMOPHOIDA, Quoy and Gaimard, l.c. p. 325, pl. LXVIII. figs. 15, 16; Tryon, l.c. XII. pl. XLIII. figs. 78-80.

Locality.—Wanganui, Petane, Matapiro.

Genus ACMÆA.

ACMÆA LACUNOSA, Reeve, Conch. Icon. *Patella*, fig. 120; Tryon, l.c. XIII. pl. XXXVII. figs. 7-11.

Locality.—Wanganui.

ACMÆA FLAMMEA, Quoy and Gaimard, l.c. p. 354, pl. LXXI. figs. 15-24; Tryon, l.c. XIII. pl. XXXVII. figs. 28-38.

Locality.—Wanganui, Petane.

Genus CHITON.

CHITON PELLIS-SERPENTIS, Quoy and Gaimard, l.c. p. 381, pl. LXXIV. figs. 17-22.

Locality.—Wanganui.

Genus ACANTHOCHITES.

ACANTHOCHITES NEOZELANICA, Quoy and Gaimard, l.c. p. 400, pl. LXXIII. figs. 5-8.

Locality.—Petane.

Class SCAPHOPODA.

Genus DENTALIUM.

DENTALIUM CONICUM, Hutton, Cat. Tertiary Moll. of N.Z. p. 1.

(Plate VIII. fig. 77.)

Shell medium, slightly curved, tapering rapidly, with from 20 to 40 longitudinal ribs at the base, decreasing to 15 at the apex; the grooves narrower than the ribs, lightly transversely striated.

Locality.—Wanganui, Petane, Patea.

DENTALIUM NANUM, Hutton, Cat. Tertiary Moll. of N.Z. p. 1.

(Plate VIII. fig. 78.)

Shell small, slightly curved, gradually tapering, with about 13 narrow longitudinal ribs, which get obsolete towards the base.

Locality.—Wanganui, Petane, Matapiro.

DENTALIUM ECOSTATUM, Kirk, Trans. N.Z. Inst. Vol. XIII. p. 306.

(Plate VIII. fig. 79.)

Shell small, slightly curved, quite smooth, polished.

Locality.—Wanganui, Petane.

Class PELECYPODA.

Genus BARNIA.

BARNIA SIMILIS, Gray in Dieffenbach's "New Zealand," II. p. 254; Reeve, Conch. Icon. *Pholas*, fig. 10.

Locality.—Matapiro.

Genus PHOLADIDEA.

PHOLADIDEA TRIDENS, Gray in Dieffenbach's "New Zealand," II. p. 254; Voy. Erebus and Terror, Moll. pl. II. fig. 8.

Locality.—Wanganui.

Genus SAXICAVA.

SAXICAVA AUSTRALIS, Lamarck; Reeve, Conch. Icon. fig. 8.

Locality.—Petane.

Genus PANOPÆA.

PANOPÆA NEOZELANICA, Quoy and Gaimard, Voy. Astrolabe, III. p. 547, pl. LXXXIII. figs. 7-9; Reeve, Conch. Icon. fig. 9.

Locality.—Wanganui, Petane, Matapiro.

Genus CORBULA.

CORBULA ERYTHRODON, Lamarck; Reeve, Conch. Icon. fig. 4; *C. macilenta*, Hutton, Cat. Tertiary Moll. p. 18.

Both valves longitudinally grooved.

Locality.—Wanganui, Petane, Matapiro.

CORBULA NEOZELANICA, Quoy and Gaimard, Voy. Astrolabe, III. p. 511, pl. LXXXV. figs. 12-14; *C. catlowæ*, Reeve, Conch. Icon. fig. 21.

Both valves finely longitudinally striated.

Locality.—Wanganui.

Genus ANATINA.

ANATINA ANGASI, Sowerby.

Locality.—Wanganui.

Genus THRACIA.

THRACIA VITREA, Hutton, Cat. Marine Moll. of N.Z. p. 61 *(Lyonsia)*; *T. granulosa*, Hutton, Cat. Tertiary Moll. of N.Z. p. 19.

(Plate IX. fig. 80.)

Shell elongato-oblong, very thin; sub-equilateral, rounded at both ends; finely longitudinally striated. Pallial sinus extending to below the umbo. Length 20 mm.; height 12 mm.

Locality.—Wanganui.

Genus MYODORA.

Key to the species.

Length equal to the height ... ... *M. neozelanica.*
Length rather more than height.
Longitudinally striated ... ... *M. striata.*
,, sulcated ... ... *M. subrostrata.*
Length one and a half times the height.
Posterior dorsal slope longer than the anterior ... *M. antipodum.*
,, ,, shorter ,, ,, ... *M. boltoni.*

MYODORA STRIATA, Quoy and Gaimard, Voy. Astrolabe, III. p. 537, pl. LXXXIII. fig. 10.

Locality.—Wanganui, Petane.

MYODORA SUBROSTRATA, Smith, Pro. Zool. Soc. 1880, p. 584, pl. LIII. fig. 6; *M. ovata*, Hutton, Man. Marine Moll. of N.Z. p. 137 (not of Reeve).

Locality.—Wanganui.

MYODORA NEOZELANICA, Smith, l.c. p. 584, pl. LIII. fig. 5.

Locality.—Wanganui.

MYODORA ANTIPODUM, Smith, l.c. p. 585, pl. LIII. fig. 7.

Locality.—Wanganui.

MYODORA BOLTONI, Smith, l.c. p. 585, pl. LIII. fig. 9.

Locality.—Matapiro.

Genus MACTRA.

Key to the species.

Shell ovate, the pallial sinus shallow.	
Posterior end rounded	*M. discors.*
Posterior end attenuated	*M. scalpellum.*
Shell oval, the pallial sinus deep	*M. lavata.*
Shell trigonal, solid.	
Pallial sinus deep	*M. æquilatera.*
Pallial sinus shallow	*M. crassa.*

MACTRA DISCORS, Gray, Voy. Erebus and Terror, Moll. pl. II. fig. 4; Reeve, Conch. Icon. fig. 17.

Locality.—Wanganui, Matapiro, Patea.

MACTRA SCALPELLUM, Deshayes, Pro. Zool. Soc. 1854; Reeve, Conch. Icon. fig. 106.

Locality.—Wanganui, Petane.

MACTRA LAVATA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 331.

(Plate VIII. fig. 81.)

Shell oval, thin, inequilateral, smooth, rather compressed. Dorsal slopes nearly straight, the posterior much longer. Ventral margin rounded. Posterior end tapering, but not truncated nor angled. The whole shell with very fine concentric lines which are seen under a lens to be crossed by excessively minute radiating lines, giving a delicate granulated appearance. Right valve with two strong anterior, and two equally strong posterior lateral teeth; short and high, the inner on each side being higher than the outer. Left valve with one lateral on each side, longer than those of the right valve. Length 23mm.; height 19mm.; thickness 11mm.

Locality.—Petane.

MACTRA ÆQUILATERA, Deshayes, Pro. Zool. Soc. 1853; Voy. Erebus and Terror, Moll. pl. II. fig. 10; Reeve, Conch. Icon. fig. 14; *M. elegans*, Hutton, Cat. Tertiary Moll. of N.Z. p. 19 (juv.).

Locality.—Wanganui, Petane.

MACTRA CRASSA, Hutton, Trans. N.Z. Inst. Vol. XVII. p 322.

(Plate VIII. fig. 82.)

Shell trigonal, sometimes nearly as high as long, massive, inequilateral, rather rudely concentrically striated. Anterior dorsal margin straight, or slightly concave; posterior dorsal margin slightly convex, longer than the anterior margin, the posterior slope barely keeled; ventral margin curved. Left valve with a single strong elongated lateral tooth on each side. Right valve (?). Pallial sinus very shallow and rounded. Length 40 mm.; height 35 mm.

Locality.—Wanganui.

Genus STANDELLA.

Key to the species.

Shell oval, thick, compressed	*S. elongata.*
Shell ovate, thin, inflated	*S. ovata.*
Shell sub-orbicular, thin	*S. rudis.*

STANDELLA ELONGATA, Quoy and Gaimard, Voy. Astrolabe, Zool. III. p. 518, pl. LXXXIII. figs. 1, 2; Reeve, Conch. Icon. *Mactra*, fig. 43; *M. notata*, Hutton, Cat. Marine Moll. of N.Z. p. 64.

Locality.—Wanganui, Petane.

STANDELLA OVATA, Gray, in Dieffenbach's "New Zealand," II. p. 251; Voy. Erebus and Terror, Moll. pl. II. fig. 2; Reeve, Conch. Icon. *Mactra*, fig. 30; *M. inflata*, Hutton, Cat. Tertiary Moll. of N.Z. p. 18.

Locality.—Petane.

STANDELLA RUDIS, Hutton, Cat. Tertiary Moll. of N.Z. p. 19.

(Plate VIII. fig. 83.)

Shell sub-orbicular, thin, compressed and rather sinuated; rudely concentrically striated. Anterior side rather shorter, its dorsal margin straight. Posterior dorsal margin arched. Anterior lateral tooth of the left valve short and high. Lower margin irregular in outline. Pallial sinus deep, rather descending, rounded at the apex. Height 60 mm.; length 60 mm.

Locality.—Wanganui, Patea.

Genus LUTRARIA.

LUTRARIA SOLIDA, Hutton, Cat. Tertiary Moll. of N.Z. p. 19.

(Plate IX. fig. 84.)

Shell elongato-oval, the height more than half the length, thick, rounded at both ends; irregularly concentrically grooved. Posterior dorsal margin straight; ventral margin convex. Cartilage pit broad and shallow. Height 63mm.; length 115mm.

Locality.—Wanganui, Petane, Matapiro.

Genus CÆCELLA.

CÆCELLA PUSILLA, Hutton, Cat. Marine Moll. of N.Z. p. 64 (*Darina*).

(Plate IX. fig. 85.)

Shell oblong, compressed, rounded at each end, inequilateral, the posterior end shorter, dorsal margin obtusely angular; the exterior finely longitudinally striated. Pallial sinus shallow. Cartilage pit directed slightly anteriorly; cardinal tooth of left valve distinct, in the right valve confounded with the anterior lateral tooth. Length 27mm.; height 14mm.

Locality.—Matapiro, Patea.

Genus ZENATIA.

ZENATIA ACENACES, Quoy and Gaimard, Voy. Astrolabe, Zool. III. p. 545, pl. LXXXIII. figs. 5, 6; Reeve. Conch. Icon. *Lutraria*, fig. 14.

Locality.—Wanganui, Petane, Patea.

Genus PAPHIA.

PAPHIA (MESODESMA) NEOZELANICA, Chemnitz; Reeve, Conch. Icon. fig. 21.

Locality.—Wanganui, Petane, Matapiro.

PAPHIA (DONACILLA) SPISSA, Reeve, Conch. Icon. *Mesodesma*, fig. 18.

Locality.—Wanganui.

Genus PSAMMOBIA.

Psammobia stangeri, Gray, in Dieff. N.Z. II. p. 253; Reeve, Conch. Icon. fig. 12.

Locality.—Wanganui, Petane, Matapiro.

Psammobia lineolata, Gray, in Yates' N.Z. p. 309; Voy. Erebus and Terror, Moll. pl. ii. fig. 11; Reeve, Conch. Icon. fig. 58.

Locality.—Wanganui, Matapiro, Patea.

Genus HIATULA.

Hiatula incerta, Reeve, Conch. Icon. *Soletellina*, fig. 13.

Locality.—Matapiro.

Genus TELLINA.

Key to the species.

1. Exterior smooth or nearly so.
   - Shell oblong, slightly folded posteriorly ... ... *T. alba.*
   - Shell ovate, strongly folded posteriorly ... ... *T. glabrella.*
2. Exterior strongly concentrically striated.
   - Shell sub-orbicular, anterior end shorter; strongly folded posteriorly ... ... *T. disculus.*
   - Shell ovate, anterior end shorter; not folded ... *T. strangei.*
   - Shell ovato-trigonal, anterior end longer ... ... *T. angulata.*

Tellina alba, Quoy and Gaimard, Voy. Astrolabe, Zool. III. p. 500, pl. lxxxi. figs. 1-3; Reeve, Conch. Icon. f. 180.

Locality.—Wanganui.

Tellina glabrella, Deshayes, Pro. Zool. Soc. 1854, p. 366; Voy. Erebus and Terror, Moll. pl. ii. fig. 7; Reeve, Conch. Icon. fig. 296.

Locality.—Wanganui.

Tellina disculus, Deshayes, Pro. Zool. Soc. 1854, p. 360; Reeve, Conch. Icon. fig. 306.

Locality.—Wanganui, Petane, Matapiro.

TELLINA STRANGEI, Deshayes, Pro. Zool, Soc. 1854, p. 362; *T. subovata*, Sowb. in Reeve's Conch. Icon. fig. 160; *T. lintea*, Hutton, Cat. Marine Moll. of N.Z. p. 67; *T. retiaria*, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 322.

Locality.—Wanganui, Petane.

TELLINA ANGULATA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 322.

(Plate IX. fig. 86.)

Shell ovato-trigonal, compressed, inequilateral, anterior end longer, strongly concentrically laminated. Posterior end slightly truncated and with a well marked fold on the left valve. Anterior dorsal margin convex, the posterior slightly concave. Right valve with two cardinals, the anterior bifid. Left valve with two cardinals, the posterior bifid. Length 33 mm.; height 21 mm.

Locality.—Wanganui.

Genus VENUS.

Key to the species.

A. Concentric ornamentation only.

1. Laminæ thin.
   - Laminæ distant; posterior truncated ... *V. yatei.*
   - Laminæ close; posterior not truncated ... *V. oblonga.*
2. Laminæ thick.
   - Laminæ 20 to 40 ... ... *V. sulcata.*
   - Laminæ 40 to 50; shell compressed ... *V. mesodesma.*
   - Laminæ 40 to 50; shell swollen ... ... *V. gibbosa.*

B. Radiately ribbed and, usually, concentrically striated.

- Ribs about 100 or more ... ... *V. meridionalis.*
- Ribs about 40 ... ... *V. stutchburyi.*

VENUS YATEI, Gray in Dieff.'s "New Zealand," II p. 250; Voy. Erebus and Terror, Moll. pl. III. fig. 11; Reeve, Conch. Icon. fig. 84.

Locality.—Wanganui, Petane, Matapiro.

VENUS OBLONGA, Hanley, Voy. Erebus and Terror, Moll. pl. II. fig. 1; Reeve, Conch. Icon. fig 1.

Locality.—Wanganui, Petane, Matapiro.

Venus sulcata, Hutton, Trans. N.Z. Inst. Vol. VII. p. 458, pl. xxi.

(Plate ix. fig. 87.)

Shell ovate, rather attenuated posteriorly; deeply and broadly concentrically grooved; about 40 concentric laminæ which are closer together near the ventral margin than near the umbo. Length 41mm.; height 35mm.

Locality.—Wanganui, Matapiro.

Perhaps distinct from *V. sulcata,* which is a Miocene species.

Venus mesodesma, Quoy and Gaimard, Voy. Astrolabe, Zool. III. p. 532, pl. lxxxiv. figs. 17-18.

Locality.—Wanganui, Matapiro, Patea.

Venus gibbosa, Hutton, Cat. Tertiary Moll. of N.Z. p. 21.

(Plate ix. fig. 88.)

Perhaps a gibbous variety of the last species.

Locality.—Wanganui.

Genus CYTHEREA.

Cytherea multistriata, Sowerby; Reeve, Conch. Icon. *Dione,* fig. 60.

Locality.—Wanganui, Petane.

Cytherea assimilis, Hutton, Cat. Tertiary Moll. of N.Z. p. 21. *(Chione).*

(Plate ix. fig. 89.)

Shell ovate, slightly attenuated posteriorly, its dorsal margin arched; anterior end rounded, its dorsal margin concave. Exterior finely concentrically striated, the striæ higher and broader at the anterior end. Length 30mm.; height 23mm.

Locality.—Wanganui.

Less elongated than *C. multistriata.*

Genus DOSINIA.

Key to the species.

Pallial sinus pointing below the anterior adductor impression	*D. australis.*
Pallial sinus pointing at the middle of anterior adductor impression	*D. subrosea.*
Pallial sinus pointing at the upper end of anterior adductor impression	*D. limbata.*
Pallial sinus pointing above anterior adductor impression	*D. grayi.*

DOSINIA AUSTRALIS, Gray, in Dieff. N.Z. II. p. 249; *D. anus*, Reeve, Conch. Icon. fig. 10.

Locality.—Wanganui, Matapiro, Patea.

DOSINIA SUBROSEA, Gray, in Yates N.Z; Voy. Erebus and Terror, Moll. pl. III. fig. 2; Reeve, Conch. Icon. fig. 19.

Locality.—Wanganui, Matapiro, Patea.

DOSINIA LIMBATA, Gould, U.S. Expl. Expd. XII. p. 422, Atlas, fig. 538.

Locality.—Wanganui.

DOSINIA GRAYI, Zittel, Reise der Novara, Palæontologie, p. 45, pl. XV. fig. 11.

Locality.—Wanganui, Petane, Matapiro.

Distinguished by the distance apart of the concentric laminæ.

Genus TAPES.

TAPES INTERMEDIA, Quoy and Gaimard, Voy. Astrolabe, Zool. III. p. 526, pl. LXXXIV. figs. 9-10; Reeve, Conch. Icon. fig. 59.

Locality.—Wanganui, Petane, Matapiro.

Genus CARDIUM.

CARDIUM STRIATULUM, Sowerby, Pro. Zool. Soc. 1840; Reeve, Conch. Icon. fig. 60.

Locality.—Wanganui, Petane, Matapiro.

Genus CHAMOSTRŒA.

CHAMOSTRŒA ALBIDA, Lamarck; Woodward, Man. Moll. pl. XXIII. fig. 14.

Locality.—Wanganui.

Genus LUCINA.

LUCINA ORNATA, Reeve, Conch. Icon. fig. 48.

Locality.—Wanganui, Petane, Matapiro, Patea.

Genus LORIPES

LORIPES CONCINNA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 323.

(Plate IX. fig. 90.)

Shell small, sub-orbicular, the umbos turned forward, truncated behind, compressed, regularly very finely concentrically grooved. Anterior dorsal margin hollowed under the umbo, then convex; posterior dorsal margin slightly convex, descending suddenly near the posterior end; anterior end sometimes slightly undulated; ventral margin rounded. Lunule lanceolate. Anterior adductor impression elongated. Teeth—right valve, one cardinal, the posterior lateral obsolete; left valve with two diverging cardinals, the laterals obsolete. Length 8mm.; height 7mm.

Locality.—Wanganui, Petane.

Genus MYSIA.

MYSIA NEOZELANICA, Gray in Dieff. N.Z. II. p. 256; Voy. Erebus and Terror, Moll. pl. III. fig. 8.

Locality.—Wanganui, Petane, Matapiro.

MYSIA AMPLA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 323.

(Plate IX. fig. 91.)

Shell sub-orbicular, thick, concentrically striated; posterior dorsal margin slightly concave, the anterior slightly arched. Interior rough, slightly radiately striated, the adductor impressions and pallial line well marked. Hinge

moderate, left valve with two diverging cardinal teeth, the anterior of which is grooved; lateral teeth obsolete. Length 39 mm.; height 37 mm.

Locality.—Wanganui.

Larger, thicker, and more strongly striated than *M. neozelanica.*

Genus KELLIA.

KELLIA ROBUSTA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 323.

(Plate IX. fig. 92.)

Shell orbiculo-triangular, nearly as high as long, compressed, nearly equilateral, very delicately regularly concentrically striated. Anterior and posterior dorsal margins nearly straight, sub-equal, the anterior rather the steeper; ventral margin and both ends rounded. Right valve with a lateral tooth on each side, both of which are nearly parallel to the margin. Anterior tooth stronger. Length 3 mm.; height 3 mm.

Locality.—Petane.

KELLIA EFFOSA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 323.

(Plate IX. fig. 93.)

Shell oblongo-triangular, nearly equilateral, rather swollen, rather coarsely, irregularly striated. Anterior dorsal margin rather concave, the posterior one rather convex; ventral margin flattened; the two ends rounded. Right valve with a lateral tooth on each side and a flattened concave portion in the centre; posterior lateral sharp and nearly parallel to the margin; the anterior thickened and curved inward, forming a deepish pit between it and the dorsal margin. Left valve with a lateral tooth on each side and a cardinal tooth in the centre, sloping backward. Length 3 mm.; height 2 mm.

Locality.—Petane.

Genus VENERICARDIA.

Key to the species.

Shell longer than high.
- Ribs broader than the grooves ... ... *V. australis.*
- Ribs about equal to the grooves ... ... *V. difficilis.*

Shell as high as long ... ... *V. patagonica*

Venericardia australis, Lamarck ; Quoy and Gaimard, Voy. Astrolabe, Zool. III. p. 480, pl. lxxviii. figs. 11-14 ; *Cardita tridentata*, Reeve, Conch. Icon. fig. 22.

Locality.—Wanganui, Petane, Matapiro.

Venericardia difficilis, Deshayes, Pro. Zool. Soc. 1852, p. 103, pl. xvii. figs. 16, 17.

Locality.—Wanganui, Petane, Matapiro.

Venericardia patagonica, Sowerby in Darwin's Geol. Obs. in S. America, p. 251, pl. ii. fig. 17.

Locality.—Petane, Matapiro.

Genus MYTILICARDIA.

Mytilicardia tasmanica, Tenison-Woods, Pro. Roy. Soc. Tas. 1875, p. 161.

Locality.—Wanganui.

Mytilicardia trigonopsis, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 324.

(Plate ix. fig. 94.)

Shell small, higher than long, strongly radiately ribbed. Ribs ten, nodular, the interstices strongly concentrically striated, anterior margin straight, long ; posterior dorsal margin short, straight, then suddenly bent down ; ventral margin regularly curved. Length 3mm. ; height 4mm.

Locality.—Wanganui, Petane.

Genus NUCULA.

Nucula nitidula, Adams, Pro. Zool. Soc. 1856, p. 51 ; Reeve, Conch. Icon. fig. 27.

Locality.— Wanganui, Petane.

Genus LEDA.

Key to the species.

Length nearly three times the height ... ... *L. concinna.*
Length less than twice the height ... ... *L. fastidiosa.*

LEDA CONCINNA, Adams, Pro. Zool. Soc. 1856, p. 48 ; Reeve, Conch. Icon. fig. 15.

Locality.—Wanganui.

LEDA FASTIDIOSA, Adams, Pro. Zool. Soc. 1856, p. 49 ; Reeve, Conch. Icon. fig. 31 ; *L. semiteres*, Hutton, Trans. N.Z. Inst. Vol. IX. p. 598.

Locality.—Petane.

Genus SOLENELLA.

SOLENELLA AUSTRALIS, Quoy and Gaimard, Voy. Astrolabe, Zool. III. p. 471, pl. LXXVIII. figs. 5-10 ; Reeve, Conch. Icon. fig. 4 ; Voy. Erebus and Terror, Moll. pl. II. fig. 13.

Locality.—Petane.

Genus ARCA.

ARCA DECUSSATA, Sowerby, Pro. Zool. Soc. 1833, p. 18 ; Reeve, Conch. Icon. fig. 81.

Locality.—Wanganui, Petane.

Genus POROLEDA.

This is a genus lately formed by Professor R. Tate.

POROLEDA LANCEOLATA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 332 (*Scaphula* ?)

Shell small, thin, compressed, smooth, much elongated, not keeled behind, very inequilateral. Anterior portion short, rounded. Posterior portion elongated, gradually tapering, truncated at the end. Posterior dorsal margin straight. Hinge line straight posteriorly, curved anteriorly, edentulous in the centre. Eight anterior and eleven posterior teeth, all nearly parallel to the hinge line. The three or four most anterior teeth are short, all the rest are elongated. From the umbo a narrow concave cartilage pit slopes very obliquely backwards and divides the two sets of teeth. Length 18mm. ; height 6mm.

Described from a right valve only.

Locality.—Petane.

Genus PECTUNCULUS.

PECTUNCULUS LATICOSTATUS, Quoy and Gaimard, Voy. Astrolabe, Zool. III. p. 466. pl. LXXVII. figs. 4-6 ; Reeve, Conch. Icon. fig. 8.

Locality.—Wanganui, Petane, Matapiro, Patea.

PECTUNCULUS STRIATULARIS, Lamarck; Reeve, Conch. Icon. fig. 27.

Locality.—Wanganui, Petane, Matapiro.

Genus MYTILUS.

MYTILUS MAGELLANICUS, Lamarck; Reeve, Conch. Icon. fig. 22.

Locality.—Wanganui, Petane.

MYTILUS LATUS, Chemnitz; Reeve, Conch. Icon. figs. 12-24.

Locality.—Wanganui, Petane, Matapiro.

Genus MODIOLA.

MODIOLA AUSTRALIS, Gray in King's Voyage, II. p. 477; Reeve, Conch. Icon. fig. 21.

Locality.—Wanganui, Matapiro.

Genus CRENELLA.

CRENELLA IMPACTA, Hermann; Reeve, Conch. Icon. fig. 64.

Locality.—Wanganui, Petane.

Genus LITHODOMUS.

LITHODOMUS STRIATUS, Hutton, Cat. Tertiary Moll. of N.Z. p. 26; Hector, Outlines of the Geology of N.Z. p. 48, fig. 4.

Elongato-oblong, umbones anterior, inflated in front and compressed behind; posterior end very finely radiately striated. Length 66mm; height 20mm.

Locality.—Wanganui.

Genus PERNA.

A large species occurs at Petane and Matapiro, but I have only seen fragments too imperfect for description.

Genus PINNA.

PINNA NEOZELANICA, Gray, in Dieff. N.Z. II. p. 259; Voy. Erebus and Terror, Moll. pl. III. fig. 7; Reeve, Conch. Icon. fig. 13.

Locality.—Wanganui, Petane, Matapiro.

Genus LIMA.

LIMA NEOZELANICA, Sowerby, Pro. Zool. Soc. 1876, p. 754, pl. LXXV. fig. 1.

Locality.—Wanganui.

LIMA (MANTELLIUM) ANGULATA, Sowerby; Reeve, Conch. Icon. fig. 13.

Locality.—Wanganui.

LIMA (LIMATULA) BULLATA, Born; Sowerby, Thes. Conch. I. pl. XXII. fig. 33.

Locality.—Wanganui, Petane.

Genus PECTEN.

Key to the species.

A. Valves not plicated.
- Ribs 11 to 15; left valve concave ... ... *P. laticostatus.*
- Ribs 20 to 25, grooved ... ... *P. triphooki.*
- Ribs 20 to 60, rough ... ... *P. neozelanica.*
- Ribs about 80, rough ... ... *P. radiatus.*

B. Valves plicated as well as ribbed.
- Plications near the umbo only ... ... *P. semiplicatus.*
- Plications extend to the margin... ... ... *P. convexus.*

PECTEN (VOLA) LATICOSTATUS, Gray, in Dieff N.Z. II. p. 260; *P. novæ-zealandiæ*, Reeve, Conch. Icon. fig. 36.

Locality.—Wanganui, Petane.

PECTEN TRIPHOOKI, Zittel, Reise der Novara, Palæontologie, p. 52, pl. XI. fig. 4.

Locality.—Moteo. Fragments only.

PECTEN NEOZELANICA, Gray, in Dieff. N.Z. II. p. 260 ; Voy. Erebus and Terror, Moll. pl. III. fig. 7 ; *P. dieffenbachii*, Reeve, Conch. Icon. fig. 88.

Locality.—Wanganui, Petane, Matapiro.

PECTEN RADIATUS, Hutton, Cat. Marine Moll. of N.Z. p. 82.

Shell orbicular, equivalve, compressed, with about 80 equal, rough radiating striæ ; thin, margin crenulated ; ears unequal. Length 43 mm. ; height 45 mm.

Locality.—Wanganui, Petane.

PECTEN SEMIPLICATUS, Hutton, Cat. Tertiary Moll. of N.Z. p. 30.

Shell sub-orbicular, compressed ; with 5 or 6 plications near the umbo, which disappear before reaching the margin ; and numerous radiating ribs ; the whole finely, but rather strongly concentrically striated. Height about 65-70 mm.

Locality.—Napier.

PECTEN CONVEXUS, Quoy and Gaimard, Voy. Astrolabe, Zool. III. p. 443, pl. LXXVI. figs. 1-3 ; *P. roseo-punctatus*, Reeve, Conch. Icon. fig. 84.

Locality.—Wanganui, Petane, Matapiro.

Genus ANOMIA.

Key to the species.

Shell thick ; only two muscular impressions	*A. stowei.*
Shell thin, smooth	*A. alectus.*
Shell thin, undulated	*A. undata.*

ANOMIA STOWEI, Hutton, Cat. Marine Moll. of N.Z. p. 83.

Shell sub-orbicular, solid, the lower valve smooth, notch large, ovate, the anterior lobe widely separated from the cardinal edge. Muscular impressions two only, the upper one large, broadly ovate or sub-orbicular, the lower one sub-orbicular, much smaller and placed on the posterior lower edge of the upper, and confluent with it. Diameter 90 mm.

Locality.—Petane, Matapiro. Fragments only.

ANOMIA ALECTUS, Gray, Pro. Zool. Soc. 1849, p. 117.

Shell thin. Muscular impressions three; the upper larger and sub-orbicular; the two lower scars close together but not confluent, about equal in size. Diameter about 45 mm.

Locality.—Wanganui, Petane.

ANOMIA UNDATA, Hutton, Trans. N.Z. Inst. Vol. XVII. p. 324.

(Plate IX. fig. 95.)

Shell broadly oval, transverse. Upper or left valve thin, rather inflated, the surface gently, rather regularly waved; the undulations taking different directions on different shells, but more or less parallel on the same individual. Muscular impressions three, confluent, forming a long oval mark sloping from before the umbo to the centre of the shell; the upper one the largest, the other two sub-equal. Length 21 mm.; breadth 17 mm.

Locality.—Petane.

Genus OSTREA.

OSTREA EDULIS, Linné; Reeve, Conch. Icon. fig. 8.

Locality.—Wanganui, Petane, Matapiro.

OSTREA CORRUGATA, Hutton, Cat. Tertiary Moll. of N.Z. p. 35; Hector, Outlines of Geol. of N.Z. p. 51, fig. 2.

Shell ovate, irregular, attached by the left valve. Left valve convex, radiately ribbed, the ribs crossed by concentric, undulating, imbricating laminæ. Right valve flat, irregular, smooth, with concentric imbricating laminar plates round the margin. Length 65 mm.; height 75 mm.

Locality.—Wanganui. Rare.

EXPLANATION OF PLATES.

PLATE VI.

Fig. 1.—*Tornatella sulcata* (× 3).
2.— ,, *alba* (× 3).
3.—*Murex espinosus* (× 2).
4.—*Trophon cheesemani* (× 3).
5.— ,, *expansus* (× 2).
6.— ,, *plebeius* (× 3).
7.— ,, *duodecimus* (× 3).
8.— ,, *crispus* (× 3).
9.—*Fusus spiralis* (nat. size).
10.—*Taron dubius* (× 3).
11.—*Siphonalia nodosa*, var. *conoidea* (nat. size).
12.—*Pisania striatula* (× 2).
13.— ,, *drewei* (× 3).
14.—*Cominella accuminata* (nat. size).
Fig. 15.—*Ancillaria lata* (× 2).
16.—*Columbella varians* (× 3).
17.— ,, *pisaniopsis* (× 4).
18.— ,, *cancellaria* (× 3).
19.—*Turricula rubiginosa* (× 4).
20.—*Terebra costata* (× 3).
21.—*Pleurotoma pagoda* (× 4).
22.— ,, *albula* (× 4).
23.— ,, *nexilis* (× 10).
24.— ,, *cheesemani* (× 2).
25.— ,, *protensa* (× 5).
26.— ,, *buchanani* (× 2).
27.— ,, *plicatella* (× 2).
28.— ,, *wanganuiensis* (× 4).
Fig. 29.—*Pleurotoma tuberculata* (× 2).

PLATE VII.

Fig. 30.—*Pleurotoma æquistriata* (× 2).
31.— ,, *alabaster* (× 3).
32.— ,, *lævis* (× 4).
33.—*Daphnella striata* (× 2).
34.— ,, *lacunosa* (× 10).
35.—*Clathurella hamiltoni* (× 3).
36.— ,, *abnormis* (× 6).
37.— ,, *dictyota* (× 6).
38.—*Natica australis* (× 3).
39.— ,, *lævis* (× 2).
40.— ,, *ovata* (× 2).
41.—*Sigaretus undulatus* (× 2).
42.—*Eulima treadwelli* (× 10).
43.— ,, *media* (× 10).
44.—*Turbonilla neozelanica* (× 6).
Fig. 45.—*Eulimella deplexa* (× 10).
46.— ,, *obliqua* (× 10).
47.—*Aclis costellata* (× 20).
48.—*Odostomia lactea* (× 6).
49.— ,, *georgiana* (× 2).
50.— ,, *fasciata* (× 10).
51.— ,, *rugata* (× 10).
52.—*Cancellaria trailli* (× 6).
53.— ,, *lacunosa* (× 2).
54.—*Admete ambigua* (× 10).
55.—*Cerithium cancellatum* (× 4).
56.—*Bittium terebelloides* (× 6).
57.— ,, *cinctum* (× 6).
58.—*Calyptræa inflata* (nat. size).
59.— ,, *alta* (nat. size).

PLATE VIII.

Fig. 60.—*Turritella tricincta* (× 3).
61.— ,, *bicincta* (× 2).
62.—*Eglisia planostoma* (× 10).
63.—*Rissoa rugulosa*(× 5).
64.— ,, *impressa* (× 10).
65.— ,, *gradata* (× 10).
66.— ,, *rugosa* (× 10).
Fig. 67.—*Rissoa annulata* (× 10).
68.— ,, *emarginata* (× 10).
69.— ,, *semisulcata* (× 15).
70.—*Vermetus moniliferus* (× 2).
71.—*Scalaria nympha* (× 10).
72.— ,, *corulum* (× 20).
73.—*Trochus conicus* (nat. size).
Fig. 74.—*Trochus chathamensis*: *a.* Upper view; *b.* side view; *c.* lower view (× 2).
75.—*Calliostoma ponderosum* (nat. size).
76.—*Megatebennus moniliferus*: *a.* Upper view; *b.* lower view (nat. size).
77.—*Dentalium conicum* (× 2).
78.— ,, *nanum* (× 2).
79.— ,, *ecostatum* (× 3).
80.—[*Vide* PLATE IX.]
81.—*Mactra lævata*: *a.* Outer view; *b.* inner view (× 2).
82.— ,, *crassa*: *a.* Outer view; *b.* inner view (nat. size).
83.—*Standella rudis*: *a.* Outer view; *b.* inner view (nat. size).

PLATE IX.

Fig. 80.—*Thracia vitrea*; *a.* Outer view; *b.* inner view (× 2).
84.—*Lutraria solida*: *a.* Outer view; *b.* inner view (nat. size).
85.—*Cæcella pusilla*: *a.* Outer view; *b.* inner view (× 2).
86.—*Tellina angulata*: *a.* Outer view; *b.* inner view (× 2).
87.—*Venus sulcata*: *a.* Outer view; *b.* inner view (nat. size).
88.— ,, *gibbosa*: *a.* Outer view; *b.* inner view (× 2).
89.—*Cytherea assimilis*: *a.* Outer view; *b.* inner view (nat. size).
90.—*Loripes concinna*: *a.*Outer view; *b.* inner view (× 4).
91.—*Mysia ampla*: *a.* Outer view; *b.* inner view (nat. size).
92.—*Kellia robusta*: *a.* Outer view; *b.* inner view (× 5).
93.— ,, *effosa*: *a.* Outer view; *b.* inner view (× 8).
94.—*Mytilicardia trigonopsis*: *a.* Outer view; *b.* inner view (× 6).
95.—*Anomia undata*: *a.* Outer view; *b.* inner view (× 2).

CORRIGENDA.

Page 46, line 9—*add* XIII. fig. 24.
Page 72, last line but one—*for* figs. 28-38, *read* figs. 78-83.

A MONOGRAPH OF THE *TEMNOCEPHALEÆ.*

By William A. Haswell, M.A., D.Sc., F.L.S., Challis Professor of Biology, University of Sydney.

(Plates x.-xv.)

CONTENTS.

I.—INTRODUCTORY.

The receipt last year from Dr. von Jhering, of Brazil, through Mr. Chas. Chilton, of Port Chalmers, New Zealand, of a new form of the remarkable genus *Temnocephala* re-directed my attention to that subject, and I have made the study of the new form the occasion for a revision of the morphology of the whole group. The examination of new forms and of better specimens of the species previously described has led to the observation of a number of new points, some of which seem to me of considerable interest and importance. In the present communication I give an account of all that is known of the family, incorporating the results of more recent observations with such as have already been published,—illustrating by figures, however, only such features as have not been already represented, or have not been represented in a sufficient manner.

I take the opportunity of expressing my thanks to Dr. A. Dendy, Professor Baldwin Spencer, Mr. Chas. Chilton, Professor T. Jeffery Parker, Sir James Hector, and Mr. Alex. Morton for supplies of specimens of various species. To Professor Spencer I am particularly indebted for specimens of the Gippsland burrowing crayfish *(Engæus fossor)*, with the *Temnocephala* that lives on its surface.

Since I published a paper on *Temnocephala** there has appeared an important contribution to the subject from Professor Max Weber of Amsterdam,† and to this I shall have frequent occasion to refer in the following pages. In 1888 was published a valuable summary of our knowledge of the Trematodes under the title "Saggio di una Morfologia dei Trematodi," by Dr. Fr. Sav. Monticelli of Naples; and the same author has also published two short papers—one entitled "Di una nuova specie del genere Temnocephala, Blanch., ectoparassita dei Cheloniani" and the other "Breve nota sulle uova e sugli embrioni della *Temnocephala chilensis*" ('Att. Soc. Ital. di scienze naturali,' Vol. XXXII.). The most important general work on the ecto-parasitic Trematodes that has appeared of late years is the part of the "Würmer" of Bronn's "Klassen und Ordnungen des Thier-reichs," by M. Braun, dealing with that group. This has been of very great assistance to me, especially in the absence of some of the original papers, such as Taschenberg's. G. Brandes has recorded various observations on the minute structure of *Temnocephala brevicornis* from Brazil‡; and

* 'Quart. Journ. Micro. Sci.' Vol. XXVIII. (1888), pp. 279-302, pls. XX.-XXII.

† "Ueber Temnocephala, Blanchard," 'Zoologische Ergebnisse einer Reise,' etc.

‡ "Zum feineren Bau der Trematoden," 'Zeitschr. f. wiss. Zool.' LIII. p. 558 (1892).

A. Vayssière* describes a new form found on the surface of the Madagascar fresh-water crayfish.

This remarkable group now proves to be of comparatively wide distribution, and to inhabit the surface of a considerable variety of animals. It has now been found in Chili, Brazil, New Zealand, Australia, Tasmania, Borneo, Celebes, the Philippines, Madagascar, and perhaps India. The various species infest the outer surface, and in one or two cases the branchial chambers, of fresh-water Crustaceans (both *Macroura* and *Brachyura)* and fresh-water Chelonians, and the branchial chamber of a Mollusc *(Ampullaria).*

That the position of *Temnocephala* in the system is not to be regarded as a settled one is evidenced by the view of the matter taken by Braun in the general work on the ectoparasitic Trematodes above referred to. He says *(l.c.* p. 520), "Temnocephala bietet allerdings eine Reihe von Besonderkeiten dar und die Frage ist trotz der Arbeiten von Haswell und Weber gerechtfertigt, ob Temnocephala ein Trematode ist." Further on (p. 521), after quoting von Graff's definition of the Turbellaria, he remarks, "Wenn man von der letzten Bemerkung über die Lebensweise, die keinen systematischen Werth besitzt, absieht, so bleibt als einziger Unterschied zwischen Turbellarien und Trematoden das für erstere characteristische Flimmerepithel der Haut mit Stäbchen oder Nesselorganen bestehen."

My renewed study of *Temnocephala* having resulted in the discovery of cilia on the surface of certain of the species, and having led to the conclusion that "Stäbchen" exactly like those of Rhabdocœle Turbellarians are present in abundance, the line of demarcation seems still harder to draw. *Temnocephala* has no near allies in either camp; but in some features of its organisation it nearly resembles some of the Monogenetic Trematodes, while in others the connection with some of the *Rhabdocœla* is extremely close. With the evidence now before me, it appears to me that the *Temnocephaleæ*, though it cannot be said that they seem to lie in a direct line between the two groups, yet unite in such an equal degree the characters of the Monogenetic Trematodes and Rhabdocœla that they may almost indifferently be ranked with either. This question is discussed more fully in the sequel.

II.—General External Characteristics.

Monticelli's and Braun's comparison of *Temnocephala* to a minute Cephalopod is very happy. The light-coloured, more slender kinds, such as *T. minor*, are, when

* "Etude sur le Temnocephala, parasite de l'Astacoïdes Madagascariensis." 'Annales de la Faculté des Sciences de Marseille,' Tome II. fasc. v. (1892).

extended, extremely like *Hydræ*, for which they have been again and again mistaken. The body of *Temnocephala* is strongly compressed dorso-ventrally, the dorsal surface being convex, the ventral flat or concave. The outline, when the animal is looked at from above, varies considerably in accordance with the extent to which the body is extended or contracted, and differs also to some degree in the different species: it may generally be described as oval or pyriform. The anterior end is provided with a series of usually five, sometimes four, sometimes six, in one species twelve, highly extensile slender tentacles, which are nearly cylindrical, but a little compressed in the dorso-ventral direction, tapering distally. In *T. quadricornis*, in which there are only four of these tentacles, there is in the middle line a short broad flattened lobe with a convex anterior border.* In *T. fasciata*, *T. minor*, *T. Dendyi*, *T. Jheringii*, *T. Semperi*, and *T. Chilensis* there are five equal tentacles; in *T. Novæ-zealandiæ*† and *T. comes* there are six. Along the lateral border, from the base of the most external tentacle backwards, there runs in some of the species a narrow fold.‡ On the ventral surface close to the posterior end is a single large, circular sucker, which in some forms is more, in others less, distinctly radiated. In front of the anterior edge of this is a median opening in the form of a small transverse slit—the common genital opening. Further forward, on the same surface, some little distance behind the bases of the tentacles, is a larger slit-like aperture—the opening of the mouth. On the dorsal surface are a pair of eyes, situated near one another, a little in front of the transverse plane in which the mouth lies. At the sides, not far from the lateral margins, and nearly in the same transverse plane as the eyes, are the small pores which form the external openings of the excretory system.

Though nearly related to *Temnocephala* as regards most essential points in its internal structure, *Craspedella* (Pl. xv. fig. 3) differs somewhat in general shape from the members of that genus. There are five anterior tentacles similar to those of *Temnocephala*, but with relatively large papillæ; and there is a large posterior sucker. But the posterior portion of the body is provided in addition with a remarkable series of papillose fringes and processes.

T. fasciata, *T. quadricornis*, and *T. Novæ-zealandiæ* are richly pigmented, especially on the dorsal surface. *T. minor* has a pigment-network which gives the animal a greyish colour to the naked eye; *T. Semperi* is only exceptionally pigmented; *T. Dendyi*, *T. comes*, and the remainder are devoid of pigment, or possess only a few scattered granules.

* See my former paper quoted above, Pl. xx. fig. 3.

† Erroneously stated to be five, *l.c.* p. 284.

‡ Braun (p. 409), misinterpreting my mention of this fold, refers to it as membrane-like appendages, a phrase which conveys an exaggerated impression.

III.—Distribution, Food, Movements, &c.

Members of this family have been found in South America, both in Chili (Gay) and Brazil (Jhering), in Australia and Tasmania (Haswell), in New Zealand (Wood-Mason), in Sumatra, Java, and Celebes (M. Weber), in the Philippines (Semper), in Madagascar (Vayssière) and in North-Eastern India (Wood-Mason). The Chilian form was found on the surface of a species of *Aeglea*, the Australian and Tasmanian species on fresh-water crayfishes of the genus *Astacopsis*, the New Zealand species on fresh-water crayfishes of the genus *Paranephrops*. In the Philippines, Java, Sumatra, and Celebes, they occur on species of *Telphusa*. The Indian form was found by Wood-Mason in bottles containing spirit-specimens of fishes to which they may originally have been attached. One Brazilian species was found on the shell of a fresh-water tortoise; the other was found as noted above, by Jhering in the branchial cavity of a species of *Ampullaria*. *Craspedella Spenceri* inhabits the branchial cavities of *Astacopsis bicarinatus*.

All, with the exception of the last two, live under ordinary circumstances on the outer surface of the animal which they select as their host.* Each species seems to be quite constant, so far as our knowledge at present extends, in its relation to a particular animal; and it very rarely happens that a *Temnocephala* is to be found under natural conditions not attached to its host.† But those forms with which I have had the opportunity of experimenting are able to live for a very long time—it might be almost said indefinitely—after removal from the surface of their host; and Max Weber made the same observation with regard to his *T. Semperi*.

When undisturbed the *Temnocephalæ* (and the same holds good of *Craspedella*), adhering by means of their sucker, either remain with the tentacles more or less contracted and the ventral surface in close contact with the surface to which the sucker is attached, or the body is raised and the tentacles stretched out widely. They move along very much after the fashion of a leech, the place of an anterior sucker being taken by the tentacles; and they show an amount of alertness and sensitiveness not usual among members of their class.‡ When an attempt is made to

* *Temnocephala Engæi* sometimes occurs in the branchial chambers; and *T. Dendyi* is very frequently found in the same position.

† Chilton has given an account (Trans. N.Z. Institute, Vol. XXI. p. 252) of his having kept specimens of *T. Novæ-zealandiæ* alive for months detached from their hosts; and he has informed me that he has found specimens of the same species attached to boulders in a New Zealand stream.

‡ *Sphyranura Osleri*, as described by Wright and Macallum, appears to be the only Trematode that approaches *Temnocephala* in this respect.

A remarkable phenomenon is sometimes to be observed when *Temnocephalæ* are placed in very shallow water in a vessel. With the sucker adhering to the bottom, one of them is occasionally observed to stretch out the tentacles and apply their ventral adhesive faces to the surface of the water, and thus, using the tension of the surface layer as a *point d'appui*, the body is drawn up to the surface of the water and the sucker applied to the latter, the animal "looping" along as if on the surface of a solid body.

remove them from the surface to which they are clinging, they are able, by flattening themselves down, and exercising all the adhesive power of the sucker and tentacles, to resist a considerable amount of force. If forcibly separated from their host and allowed to fall towards the bottom of the water, they twist and writhe themselves about during their passage downwards, so that they often succeed in laying hold of some prominent part of their host's body and reinstating themselves on its surface.

As regards the nature of their food, the *Temnocephalæ* differ widely from the Trematodes. For the most part they live on small *Entomostraca* and Insect-larvæ, as well as Rotifers, all of which they swallow whole. The prey is seized and thrust into the mouth by means of the tentacles. Sometimes the animal is found in the act of making a vain endeavour to swallow an Entomostracan nearly as long as itself. Whole small animals of such sorts have been found by myself in the intestine of *T. fasciata*, *T. minor*, *T. Dendyi*, *T. quadricornis*, and *T. Novæ-zealandiæ*, and by Max Weber in *T. Semperi*, sometimes accompanied by numerous diatoms and unicellular algæ. In *T. Dendyi* I have in one instance found an entire and quite unaltered smaller individual in the alimentary canal of a larger one, and in several instances in *T. Novæ-zealandiæ* I have found the chitinous parts (cirrus and vaginal teeth) of one in the intestine of another, the soft parts having apparently been digested. But in some specimens of *T. fasciata* I have observed that, when the crayfish host carried eggs, the alimentary canal was full of red matter resembling the yolk, and though it is unlikely that the Trematodes are able to break into the eggs (which are far too large for them to swallow whole), yet it would seem as if they swallowed the contents of such of them as became accidentally bruised. In the case of *T. comes* the intestine either contained a reddish granular matter of this kind, or a quantity of mud with sand-grains, diatom-valves, etc., and the remains of Arthropods were never observed.

In *Craspedella Spenceri* I have only found various unicellular organisms; in four or five instances a number of large green unicellular organisms, which could not be identified, but which looked like *Euglenæ*. *Craspedella* is not adapted, owing to the absence of the muscular pharynx, to preying on the relatively large living animals that form the food of *Temnocephala*.

IV.—THE INTEGUMENT.

The most noteworthy feature of the integument in *Temnocephala* is the presence, in the adult state, in two species at least, of a coating of vibratile cilia. It is quite possible—though it does not seem likely—that a careful re-examination of some of

the other monogenetic forms may lead to a similar discovery with regard to them, and thus the distinction in this respect between the Trematodes and the *Turbellaria*, usually supposed to be absolute, may be broken down. But, so far as our present information goes, *Temnocephala* occupies in this respect, as in certain others, a quite unique position if it be regarded as a Trematode. When I published the previous paper already referred to, I had entirely overlooked this remarkable fact, owing to my having at my command only spirit-specimens of the species *(T. minor)* in which the structures in question are best developed. In this species the cilia are most numerous and active immediately behind the tentacles; but in many individuals are present in more scattered fashion over the rest of the surface, with the exception of the tentacles and the sucker, on which they never occur. In *T. Dendyi* they are less numerous than in *T. minor*, and I have only hitherto succeeded in detecting their presence in that species towards the lateral border of the body on the dorsal aspect just behind the bases of the tentacles, from which point they extend backwards a considerable distance beyond the excretory sac, though never as far as the middle of the body. Where they occur they stand in marked contrast to the non-motile cilia of the tactile cones about to be described—being curved, highly flexible and whip-like; they are intermediate in character between ordinary cilia and the flagella (Geisseln) that occasionally occur here and there on the surface of a Rhabdocœle Turbellarian. They do not occur in *T. fasciata* nor in *T. Novæ-zealandiæ* at any stage. Both Semper and Weber state that they are absent in *T. Semperi.*

A second set of integumentary structures, previously overlooked by me and not noticed by Weber or Braun, seem to be universally present. These are minute elevations in the form of truncated cones (·005 mm. in height in *T. fasciata)* which occur abundantly on the anterior part of the body and on the tentacles (Pl. x. fig. 1, *t. c.*); each has at its summit a little fasciculus of non-motile cilia. In all probability these are integumentary sense-organs, and, though I have not completely traced a direct connection with nerve-fibres, it would seem likely that they form the end-organs of the extremely complex subcutaneous nerve-plexus, since numbers of nerve-fibres are given off from the transverse branches of the dorsal nerves and run straight through the layer of longitudinal muscular fibres towards the epidermis. Similar structures, differing somewhat in shape, have been described by Wright and Macallum* as occurring in *Sphyranura Osleri*, and have been named by them the 'tactile cones."

The integument in *Temnocephala* and *Craspedella* is unique among Trematodes in consisting of three well-defined layers, which may be termed cuticle, epidermis, and basement membrane. The *cuticle* (Pl. x. figs. 1, 2, 7 and 8, *cu.*) is readily discernible

* "*Sphyranura Osleri:* a Contribution to American Helminthology." 'Journ. of Morphology,' Vol. I. p. 9, pl. I. fig. 2.

in the living animal as a clear layer superficial to the epidermis; it varies considerably in thickness in the different species: the thickness is greatest—·004 mm. in *T. fasciata;* in *T. comes, T. Dendyi* and *T. Novæ-zealandiæ* it is nearly as great; in *T. minor* it is much more delicate and considerably thinner than the epidermis, the thickness of the entire integument (including cuticle, epidermis and basement membrane) in this species being only ·006 to ·008 mm. In *T. Jheringii* it is still thinner—·003 mm. In all the species it and the other layers are much thinner on the tentacles and the suckers than elsewhere. It is of homogeneous character, but perforated by the openings of numerous pore-canals continuous with those of the underlying layers. Its surface, in the case of *T. fasciata* and *T. comes*, is thrown into numerous regular minute rugæ, which, however, are probably not present when the animal is fully extended. In sections of specimens that have been well fixed and hardened its outer surface appears, in the case of some species, to be covered with minute blunt papillæ (Pl. x. fig. 6), between the bases of which are the apertures of the pore-canals; these papillæ do not occur in all the species; I have observed them in the case of *T. fasciata, T. comes* and *T. Novæ-zealandiæ;* they are absent in *T. minor* and *T. Dendyi.*

Below the cuticle is a distinct nucleated protoplasmic layer or epidermis (Pl. x. figs. 1-8, *ep.* and Pl. XIV. fig. 4, *ep.*). Weber describes this as a layer of cells of cubical form, but varying somewhat in shape with the state of contraction or extension of the part, with indistinct, or altogether without, cell-outlines.* I have never been able to see any trace of cell-outlines, though I have examined preparations treated by every method likely to be favourable to their detection if present (impregnation with nitrate of silver among the number); and I therefore prefer to adhere to the view that, though this epidermal layer is developed from a layer of rounded cells, yet in the adult condition we have to do with a complete syncytium, and not with a layer of cells as such.†

In all the species examined this epidermal layer is striated in a vertical or slightly oblique direction. Many of the lines or striæ are produced by the pore-canals, the openings of which are to be observed on the surface of the cuticle; but they seem to be too numerous to be all capable of being accounted for in this way; and there is some sort of vertical fibrillation of the protoplasm as well, due apparently to the presence of closely-set slender columns similar to those described by Böhmig as occurring in the epidermal cells of Rhabdocœles. This marking is particularly distinct in *T. quadricornis* (see Pl. XIV. fig. 4). In many sections the pore-canals are distinctly to be seen as vertical channels running through the epidermis, sometimes very narrow, sometimes comparatively wide. In tangential sections (Pl. x. fig. 4) it

* Weber, *l.c.* p. 5.

† Braun (*l.c.* p. 422) comes to the same conclusion as regards the absence of cell-outlines.

is seen that these channels communicate in such a way as to form a network through the protoplasm of the epidermal cells. They are frequently dilated into rounded spaces, which vary considerably in size under different conditions. In specimens fixed with osmic acid, they are never very wide; they are wider in sections of specimens fixed with Flemming's solution and still more dilated in specimens fixed with picrosulphuric acid and afterwards subjected to maceration. They are distinct, though not large, in sections of specimens fixed with picrosulphuric acid and with corrosive sublimate and acetic acid. Those spaces, which are without doubt the same as the "wasser-klare Räume," the existence of which in the epidermis of the Turbellaria has long been known and frequently been referred to, occur towards the outer ends of the canals. Max Schultze's* and Böhmig's† account of these spaces in the Turbellaria would, in fact, very well apply to the case of *Temnocephala.* They were overlooked by me when I wrote my previous paper on this subject; and to Brandes‡ is due the credit of first publishing an account of them in *Temnocephala.* As they are discernible in specimens prepared by so many methods, they are probably present in the living condition of the animal; but I am disposed to think that whenever they appear of any considerable size in preserved specimens it is owing to the action of re-agents. Such spaces are not distinguishable in the living unaltered state; but when a little acetic acid is applied, rounded clear spots soon make their appearance and increase in size. A similar effect is produced by pressure—the clear spaces by-and-bye increasing till they form blisters projecting on the surface. Max Schultze's account of this phenomenon in the Turbellaria applies word for word to *Temnocephala*—"Wirkt Wasser längere Zeit auf die Haut eines solchen einem ziemlich starken Drucke ausgesetzten Thieres ein, so nehmen die hellen Räume der Haut allmählig durch Imbibition an Umfang zu, erheben sich über die Oberfläche, indem sie die Grundsubstanz vor sich her drängen, und die Cilien auf die Seite schieben, werden immer blasser, und platzen endlich um sofort ganz zu verschwinden."§ When acetic acid is seen to produce this effect, it is easy to understand that such fixing solutions as contain that or similar acids are likely to cause dilatation to a greater or less extent. In *T. quadricornis* these spaces appear to be entirely absent —the very numerous narrow pore-canals running directly through the epidermis.

The nuclei of the epidermis are usually spherical or oval, but may be compressed in a direction vertical to the surface; their form appears to vary in a greater or less degree with the state of contraction or extension of the body. In *T. minor* they are vertically elongated in the tentacles, flattened elsewhere. They have no definite nucleoli, but a closely coiled chromatin filament. In size they differ considerably in

* "Beiträge zur Naturgeschichte der Turbellarien," p. 9.

† "Untersuchungen über Rhabdocöle Turbellarien." 'Zeitschr. f. wiss. Zool.' LI. (1891).

‡ "Zum feineren Bau der Trematoden." 'Zeitschr. f. wiss. Zool.' LII. (1892).

§ *Loc. cit.* p. 9.

the different species: in *T. minor* they are ·004 mm. in diameter, in *T. Jheringii* ·005 mm., in *T. fasciata* ·0035 to ·0075 mm.; while in *T. quadricornis* they reach the relatively large size of as much as ·02 mm. in some cases. They are scattered at fairly regular intervals over the surface—about ·02 to ·04 mm. apart in the Australian species, more widely separated in *T. Jheringii.*

These two layers—the cuticle and the epidermis—are, as already mentioned, distinguishable in the living condition, the cuticle appearing as a well-defined narrow clear band, superficial to the more granular-looking epidermis; they are separable, though not always readily, by maceration. In sections stained in various ways they are clearly differentiated, especially if picrocarmine be the staining agent employed. In specimens that have been fixed by means of osmic acid solutions the differentiation is usually not so clear—the acid darkening both layers and preventing staining agents from producing a differentiating effect.

Underlying the epidermal layer is a very definite, homogeneous, non-nucleated basement membrane (Pl. x. figs. 1, 2, 7 and 8, *b. m.*; Pl. XIV. fig. 4, *b. m.*), usually of nearly the same thickness as the epidermis, but varying a good deal in this respect, in accordance apparently with the condition, as regards contraction or relaxation, of the specimen or the part. Under ordinary conditions it is thicker on the dorsal surface than on the ventral; excessively thin on the tentacles and ventral surface of the sucker. This layer is present in all the species I have examined; but is absent according to Weber in *T. Semperi*, the epidermis in that species resting directly on the layer of circularly arranged muscular fibres. I have called it homogeneous, as in the vast majority of sections, and in macerated and teased preparations, it has the appearance of being so; but in one series of sections of *T. Dendyi* prepared by Flemming's method it presents (Pl. x. fig. 8, *b. m.*) a very minutely reticulate structure only distinguishable under a high power. This is not in any way comparable to the complex arrangement of cells and processes described by Lang as characterising the basement membrane in the *Polycladidæ*.* By many staining processes the basement membrane is not affected, and thus stands out in marked contrast, as I have endeavoured to show in fig. 2, to the epidermis on the one side and to the layer of circular muscular fibres on the other; but some carmine solutions stain it intensely—much more so than the epidermis. When a specimen which has been stained with picrocarmine is teased, the basement membrane is usually readily discernible, owing to its being brightly stained and exhibiting a firmer consistency than the other layers. Adhering to its inner surface in such preparations are found scattered fibres partly belonging, apparently, to the circular layer, partly to the muscular system of the parenchyma. It is perforated by the pore-canals, but these are difficult to see,

* "Die Polycladen," p. 64.

though clearly distinguishable in some sections, except when the secretion of the integumentary glands is passing out through them; they frequently branch and anastomose in their passage through the basement membrane as in their passage through the epidermis.

This layer has to some extent a skeletal function, as postulated by Lang* for the corresponding layer in the *Polycladidæ*—the very extensively developed system of muscular fibres of the parenchyma being, for the most part, inserted into it.

G. Brandes† has recently studied the structure of the integument in *T. brevicornis*, and has failed to distinguish clearly the layers described above. But the material which he had to work with was collected as long ago as 1856; and perhaps his failure, as he himself acknowledges, may have been due entirely to the imperfect preservation of his specimens. It is possible, however, though I scarcely think it likely, that the South American species, which, so far as they have been studied, appear to differ somewhat widely from those found in Australasia, may have an integument of a simpler character. Our author himself thinks that the difference is not a specific one, for he says—" Wenn nun meine Beobachtungen über die Körperbedeckung dieses 'abweichend gebauten Trematoden' mit den Angaben der bisherigen Forscher nicht übereinstimmen, so liegt dies nur zum geringsten Theile daran, dass ich eine andere Species untersucht habe, denn aus dem Vergleich meiner Befunde mit den veröffentlichten Thatsachen glaube ich mit Sicherheit schliessen zu können dass die neue Form mit der bisher beschriebenen in den wesentlichsten Punkten wenigstens übereinstimmt, und dass die bezüglichen Verhältnisse eine falsche Deutung erfahren haben" (p. 571).

After quoting my account of the layers in question he goes on to say—" Die Abbildung, die Haswell von diesen Verhältnissen giebt und die auch Braun reproducirt, ist etwas sehr schematisch gehalten; unter dem Mikroskop wird man derartige Bilder kaum zu Gesicht bekommen. Ja—ich meine dass man—ohne die Form untersucht zu haben—lediglich auf Grund der von Haswell gegebenen Abbildung und dem dazu gehörigen Texte der Abhandlung sehr wohl berechtigt ist an der Richtigkeit der Darstellung zu zweifeln. Denn Abbildung und Text stimmen durchaus nicht zusammen. So schreibt unter Anderem Haswell dass die Epidermis auf Querschnitten 'into a series of vertical columns' durch eine Anzahl von Parallellinien getheilt zu sein scheine und dass dieses Aussehen durch eine grosse Menge von Porenkanälen hervorgebracht werde, die sowohl Epidermis als auch Cuticula durchsetzen. Vergleichen wir mit dieser Schilderung die Abbildung (Taf. XXI. fig. 1), so finden wir, dass die Porenkanäle der Cuticula und die der Epidermis ein

* *Loc. cit.* p. 65.

† " Zum feineren Bau der Trematoden." 'Zeitschr. f. wiss. Zool.' LIII. Bd. (1892).

ganz verschiedenes Aussehen haben, die letzteren sind ausserordentlich viel voluminöser, sodann bilden die einen gar nicht die Fortsetzung der anderen, sondern sind ganz unabhängig von ihnen. Ausserdem muss es aber auch auffallen, dass die kräftigen Kanäle sich nicht weiter in die homogene 'Basalmembran' verfolgen lassen."

To this I have to reply that the figure in question is not extremely diagrammatic—being in reality a very fair representation of what is to be seen in a section of the integument of *T. fasciata*, and, as far as the cuticle, epidermis and basement membrane are concerned, a photograph would give a very similar picture. The parts of the canals that are situated in the epidermis are certainly wider than those in the cuticle; in imperfectly preserved or partially macerated specimens they become very much more dilated. I did not make the lines in epidermis and cuticle coincide because, as a matter of fact, they do not do so.

Let us proceed to examine Brandes's own account of these layers.

He states that he also finds in *T. brevicornis* an integument consisting of three layers. But he was not able with certainty to distinguish these from one another. The superficial part, he considers, might as well be regarded as a superficial part of the whole "cuticular layer" which had undergone a certain modification through contact with the water, and the lowest layer—the basal membrane—may be reckoned as also part of the cuticle,* or as a delicate outer layer of the parenchyma, or as circular muscle-layer. But, he adds, the blame for these negative results may be laid on the smallness of the elements and their imperfect preservation. He then proceeds to describe in the middle layer the spaces above referred to but not previously noticed by me, and traces their connection with the pore-canals.

All this is not readily to be reconciled with the passages I have quoted, and I am at a loss to see what is the "falsche Deutung" which he regards himself as having detected.

V.—MUSCULAR LAYERS.

In the wall of the body there are three layers of muscular fibres—an external thinner layer with transversely or circularly arranged elements, an internal, much thicker layer in which the fibres run longitudinally, and an intermediate layer of intercrossing diagonal fibres. The first (Pl. x. figs. 1, 2, 7 and 8, *c. m.*) lies immediately below the basement membrane; in some of the species it is separated from the internal layer by a tolerably thick zone of parenchyma containing pigment.

* I do not understand why Brandes should prefer to use the word *cuticle* here, seeing that he acknowledges the presence of nuclei. It is true that in the explanation of the plates he calls these "kernartige Gebilde"; but no uncertainty as to their nature is expressed in the text. To call a nucleated protoplasmic layer a cuticle is, to say the least, very unusual.

It does not vary much in thickness in different parts, and is always very thin—a single layer in *T. Dendyi.* The layer of longitudinal fibres, which varies considerably in thickness, but is always much thicker than the circular layer, is divided into a number of parallel bundles by slight interspaces of parenchyma usually containing pigment. On the ventral side of the body this longitudinal layer is much thicker than on the dorsal; on both surfaces it thins out towards the lateral borders; on the ventral side it is divided into irregular narrow bundles, which are more numerous laterally; on the dorsal side it is also divided, here and there, by narrow strands of parenchyma. Weber rightly points out that the fibres of the longitudinal layer are by no means all exactly longitudinal. The prevailing longitudinal direction of the fibres is particularly modified on the ventral side, where the division of the layer at the bases of the tentacles and at the sides of the mouth and genital aperture produce a greater or less degree of obliquity.

These muscular fibres of the body-wall are usually angular, sometimes rounded, in transverse section, ·004 mm. in diameter in the case of the longitudinal, rather less in that of the circular fibres. They are devoid of nuclei, finely striated in the longitudinal direction, embedded in finely fibrillar interstitial matter. In cross-section they sometimes appear to contain an axial darker core surrounded by a clearer cortical substance.

The account of the musculature in *Temnocephala brevicornis*, given by Brandes in the paper already quoted, is in certain important respects different from that given above. He speaks of the fibres as hollow, or as giving the impression of a tube "durch Anordnung der kontraktilen Substanz im Umkreise der ursprünglichen Zelle." This is particularly distinct, he states, in the longitudinal layer, which, he adds, "Haswell durchaus falsch abbildet und schildert." "Auch hier treten die kontraktilen Röhren zu einem auf Querschnitten netzartig erscheinenden Gewebe zusammen das sich ganz allmählich in das parenchymatische Bindegewebe fortsetzt. Mir scheint der letztere Umstand für die Genese des Trematodenparenchyms, die meines Erachtens durchaus noch nicht aufgeklärt ist, beachtenswerth zu sein; ich werde bei anderer Gelegenheit darauf zurückkommen."

The above account of the longitudinal muscle-layer is totally at variance with what I have found in all the species I have studied, and I am disposed to think that this may be due to the imperfect state of preservation of the specimens. To this is certainly due the description of the muscular fibres as having the appearance of tubes—an appearance which I have repeatedly observed in specimens the preservation of which had been doubtful, but which is rarely seen in specimens that have been properly fixed by means of a corrosive sublimate or osmic acid solution: at most this is a preparation phenomenon.

He further points out the presence of the layer of diagonally disposed fibres previously overlooked.

The muscular fibres of the sucker are a specially developed part of the muscular layers of the body-wall, with the addition of elements from the parenchyma muscle. Six sets of fibres are to be distinguished:—(1) Fibres which pass from the dorsal wall of the body to near the centre of the concavity of the sucker; (2) oblique fibres which run through the substance of the outer part of the sucker from the dorsal to the ventral surface; (3) fibres which run longitudinally from the ventral body-wall obliquely through the lateral parts of the stalk; (4) radial fibres; (5) circular fibres running round the margin; (6) accessory fibres.

VI.—INTEGUMENTARY GLANDS.

The very remarkably developed unicellular glands have received a fair amount of attention both from Weber and myself; but one or two points of some importance remain to be noticed.* Weber rightly remarks that I had understated the extent of the region of the body in which these unicellular glands are found. They are chiefly arranged in a broad band near the lateral borders of the body from the terminal sac of the excretory system in front to the sucker at the posterior end. They are large cells—as much as ·075 mm. in long diameter—mostly elongated in the dorsi-ventral direction. At its ventral end, as pointed out by Weber, each cell narrows to a process which acts as the duct. The cell has a large nucleus (·012 mm. in diameter in *T. fasciata*). This is enclosed in a thick nuclear membrane and contains a single spherical nucleolus with a network of achromatin fibres. The protoplasm usually contains many of the rod-like bodies described below: sometimes it presents an open network of fine branching threads, for the most part radial in direction; sometimes the network is close and dense. The rod-like bodies in the protoplasm of the cell are brought out most clearly in corrosive sublimate specimens stained with hæmatoxylin, which colours the rods much more strongly than the protoplasm.

The secretions from these glands find three principal destinations, and, consequently, the glands themselves may be arranged in three groups. The glands of the first group—the tentacular glands—send their secretion forwards to the tentacles (Pl. XIV. fig, 1, *t. g.;* Pl. XV. fig. 1, *r. g.*). Those of the most posterior set—the acetabular—are connected with the sucker. The secretion from the cells of the third group passes to the ventral surface of the body in the neighbourhood of the genital

* As Weber points out, these unicellular glands cannot be regarded as modified cells of the parenchyma, but are almost certainly greatly produced epidermal cells, the body of which has become sunk deeply beneath the surface, with which the cell only remains connected by the greatly elongated narrow process constituting the duct.

opening. There is no line of demarcation between these sets of cells, nor are the groups distinguishable except by tracing out the course followed by the ducts, the several sets being more or less intermingled.

In each of the cells of the first two sets there are developed innumerable minute rod-like bodies ·0075 mm. in length* (in *T. fasciata),* sometimes straight, usually slightly curved, and usually slightly dilated at the ends. These rods pass out through the duct, which runs forwards, forming, along with the ducts of neighbouring cells, a tolerably thick strand passing towards the bases of the tentacles, the individual ducts branching and anastomosing. In front there is usually a slight dilatation of the strand *(vide* Pl. xv. fig. 1, *r. d.)* which would seem to indicate the presence of a dilatation of the constituent ducts, apparently to form small reservoirs for the secretion. From this point some of the ducts pass to the integument behind the bases of the tentacles ; most of them pass along the axes of the tentacles, ramifying and anastomosing as they go. Finally the terminal branches open on the exterior through the pore-canals all over the ventral surface of the tentacles and the integument of the body some distance behind the bases of the latter.

Through this system of ducts the rod-like bodies pass forwards, moved, apparently, by the general contractions of the muscles of the body-wall and parenchyma, and they are usually found packing the interior of the branching channels in the tentacles. From these they pass out, one by one, through the pore-canals, accompanied by a glutinous fluid. It is this secretion containing these rod-like bodies that would appear to give the tentacles their adhesive power when laid flat on a smooth surface. When the tentacles are separated from the surface of a glass slip on which the animal has been placed, the surface of the glass retains adhering to it a large number of the rods with a layer of the viscid fluid in which they are embedded. Like the corresponding secretion in the Rhabdocœles, as held by v. Kennel,† Böhmig,‡ and others, this secretion probably aids in the capture of struggling prey by clogging and hampering their movements.

Behind these tentacular glands are the acetabular glands, the secretion of which reaches the exterior on the inner surface of the sucker. Usually these are situated far back near the base of the sucker. In essentials they resemble the tentacular glands, and their secretion is of a similar character ; its function appears to be to add to the adhesive power of the sucker.

* The length is given as ·02 mm. in my former paper ; this is an error, since it would make the rods about a fourth of the diameter of the whole cell.

† "Untersuchungen an neuen Turbellarien." 'Zool. Jahrbücher,' 1889.

‡ *Loc. cit.*

After a *Temnocephala* has remained at rest for some time on one spot on the surface of a glass vessel, when it moves it leaves behind it a circular cloudy mark where the sucker had been adhering. When a number of them have been kept for a day or so in a small vessel, the bottom is found to be covered with a slimy layer, which may be removed as a thin pellicle. This proves on microscopic examination to be a colourless jelly, through which myriads of the rods are scattered—the whole very closely resembling a *Zooglœa.*

The glands above described are undoubtedly the equivalents of the rhabdite-forming glands as they occur in the Rhabdocœle Turbellaria. The character of the cells, the nature of the bodies developed in them, the arrangement of the ducts in strands ("Stäbchenstrassen") and their distribution about the anterior end of the animal all closely correspond. Whether in *Temnocephala* the cells that form the rhabdites also produce the viscid matter in which they lie, or a special set of the cells have that function, as occurs, according to v. Graff, in the Rhabdocœles, is uncertain: I incline to the former view, each rod, as it lies in the cell, being surrounded by a zone of uncolourable clear matter which is probably the viscid matter in question. As to the special function of the rhabdites, it is possible they have some influence on the consistency of the secretion—making it thicker or increasing its glutinous qualities. It is possible that they are themselves of a glutinous consistency, and aid in cohesion when in the act of protruding from the openings of the pore-canals. But this latter view seems no more probable than Schultze's* theory that they have an influence on the tactile sensibility of the surface by offering resistance to pressure in the same fashion as nails and similar hard structures: it seems very unlikely that a function of this kind would be performed by bodies that are being cast off constantly by hundreds. Von Graff's observation† that the rhabdites are most abundant towards the anterior end, and much more numerous in sensitive and active forms, would seem to indicate that they have some function—unless we are to look upon them as an excretion—but does not seem to tell very specially in favour of Schultze's theory.

Much less numerous and less constantly in action are certain of the integumentary glands, the secretion of which passes to the ventral surface of the body around the genital aperture. Only exceptionally are the pore canals in this region found to be charged with the secretion, which contains solid elements shorter and thicker than those of the tentacular glands. The secretion is in this case most probably utilised to form the viscid material by means of which, in some of the species, the eggs, as will subsequently be explained, are united together when laid.

* "Beiträge zur Naturgeschichte der Turbellarien."
† *Tom. cit.* p. 58.

VII.—THE PARENCHYMA.

The complex ramifications of the nerve-tubes, the branches of the excretory vessels, the unicellular glands and their ducts, and the bands of muscular fibres that extend from one surface of the body to another, or from organ to organ, take up so much of the space between the body-wall and the digestive and reproductive organs that the quantity of parenchyma is not relatively very great. Where it occurs uncomplicated by other elements, it presents the appearance of a close reticulum of delicate fibres, which, where they anastomose, sometimes present plate-like expansions. Dotted here and there at wide intervals are to be found oval nuclei ·012 mm. in diameter (Pl. x. fig. 9), which seem to be the only nuclei specially appertaining to the parenchyma proper. In osmic acid preparations the meshes of the network are found to be occupied by a more delicate reticulum. To judge by its behaviour under the action of staining agents, this network of fibres is not of protoplasmic character, having undergone a sufficient amount of modification to render it incapable of being readily coloured. It is likely that the whole tissue in the living animal is filled like a sponge, not with hyaloplasm, as stated by Böhmig with reference to the Rhabdocœles, but with a watery fluid containing a certain amount of coagulable matter. Probably the parenchyma is to be regarded as composed of large cells with the nuclei above described, without cell-boundaries, and with a protoplasmic reticulum which has become greatly vacuolated.

In addition to the cells already described and those to be referred to later as excretory cells, there occur embedded in the parenchyma, here and there throughout the body, groups of cells which appear to have no connection with any of the systems of organs, and which I referred to in my former paper as parenchyma cells.* These (Pl. x. fig. 10) are comparatively small cells, about ·01 mm. in diameter in *T. fasciata*, which occur rarely singly, nearly always in clumps of ten or twelve closely aggregated together. They have oval nuclei ·0025 mm. in long diameter, with a minute spherical nucleolus and other smaller scattered particles of chromatin. In several cases they were observed to be dividing with mitosis. They are very like the nerve-cells but much smaller.

In the parenchyma of certain of the species—*T. fasciata, T. quadricornis, T. minor, T. Novæ-zealandiæ*—there is more or less pigment. In *T. fasciata* this is very abundant—chiefly taking the form of a fine close network of very delicate threads of

* Braun inadvertently states that I described the parenchyma cells as star-shaped. This is not the case; I did not give any special account of them. The star-shaped cells which appear in several of my figures correspond to what are described in the present paper along with the excretory system.

granular pigment* (Pl. x. fig. 1) lying superficial to the layer of longitudinal muscular fibres, but extending also in exceedingly fine scattered filaments throughout the whole thickness of the parenchyma, and, as in certain Rhabdocœles, according to Böhmig, entering into the central substance of the cerebral ganglion. In the case of *T. quadricornis* (Pl. XIV. fig. 4) the pigment is also partly between the two layers of muscle, but is in great measure diffused throughout the whole of the underlying parenchyma; in this species it appears as regular larger and smaller spherical granules instead of threads. In *T. Novæ-zealandiæ* (Pl. x. fig. 7) it is much the same, except that the granules are smaller and less uniform. In *T. minor*, on the other hand, the pigment is almost completely confined to the zone underneath the layer of circularly-arranged muscular fibres, where it is arranged in the form of a network of limited extent with coarse irregular meshes, the pigment here appearing, when examined under a high power, in the shape of minute rounded granules.

Muscular fibres are very numerous in the parenchyma of *Temnocephala*. They are slender fibres with small nuclei, either running singly or in bundles. Most of them are dorsi-ventral in their course, with varying degrees of obliquity: at their extremities they are inserted into the basement membrane. These dorsi-ventral bundles are especially numerous in *T. fasciata*. They are intimately united with the network of the parenchyma, and perforate certain of the large cells lying therein. The muscular layers which invest the various organs are of the same character as these dorsi-ventral fibres; but these may be conveniently considered along with the organs they enclose.

VIII.—ALIMENTARY CANAL.

The mouth, as already noticed, is on the ventral surface a little behind the level of the eyes and the excretory openings. When closed it is in the form of a transverse slit with folded and puckered edges; but it is capable of being opened very widely, so as to admit of the passage of comparatively large objects. The mouth leads almost directly into the pharynx, a mouth-cavity being here represented only by a very small space, lined by a continuation of the integument. The unicellular glands, which Weber represents as opening in this position, do not occur in any of the species I have examined.

The pharynx of *Temnocephala* is a muscular bulb of rounded shape (pharynx bulbosus) with walls of very firm and tough consistency. Its antero-posterior, vertical and transverse diameters are almost equal; it occupies about a half to a

* These are not stellate pigment cells as supposed by Braun; in fact, they are not cells at all.

third of the breadth of the body, and, in its thickest part, four-fifths of the thickness. Its dorsal and ventral walls are thicker than its lateral. It contains a cavity which, probably rounded in the distended, is usually compressed and tri-radiate in the contracted condition. Its internal lining membrane is a thick layer of almost homogeneous character, very finely granular and very finely striated in a vertical direction—the striæ appearing under a high power as rows of dots. This layer is not cuticular in character, and, though devoid of nuclei, must, I think, represent the internal epithelium. A continuation of the surface epithelium into the interior of the pharynx as described by Weber is not recognisable in my sections; but in some there appears to be a very thin inner layer, which may be an internal cuticle. The greater part of the wall of the pharynx is composed of muscular fibres which are readily distinguishable into the following layers.* Most externally is a complete coating of circular (transverse) fibres; and most internally next to the epithelium is an internal layer, the fibres of which run in the same direction. Between those extend numerous radial fibres arranged singly or in narrow bundles; these are separated from one another by interspaces containing parenchyma; each splits up both externally and internally into several branches. Running between the outer ends of these radial fibres are the fibres of a thin external longitudinal layer, and a similar longitudinal layer runs between their inner ends. At the anterior and posterior ends of the pharynx very closely arranged circular fibres fill the interspaces between the radial fibres and to a great extent displace them; slender radial fibres divide those into tolerably regular bands.† Strands of parenchyma muscle passing from the outer circular layer towards the integument have probably the function of protractors and retractors.

Between the muscular layers there runs a system of visceral nerves, with occasional bipolar ganglion-cells, to be afterwards referred to.

In the wall of the pharynx between the radial muscular fibres are numerous large cells with processes, which in some instances anastomose. They have large nuclei—·0175 mm. in diameter in *T. fasciata*, smaller in *T. Dendyi*, with a single rounded nucleolus in the former case, and with several small chromatin masses in the latter. In the latter species these cells send processes inwards between the radial muscular fibres, forming narrow ducts along which a bright oily-looking secretion passes to enter the internal cavity of the pharynx. These ducts were not seen in the other species; but it is not likely that they are absent. The cells are thus of

* In my former paper there is an unfortunate mistake in the account of the layers of muscle in the wall of the pharynx. Fig. 6 of Pl. XXI. is a drawing of a part, not of a *longitudinal* (as stated in the explanation of the plates), but of a *transverse* section, and in the account of the arrangement (p. 290) the order of the layers is reversed in accordance with this. The thick anterior and posterior masses of circular fibres were overlooked altogether.

† These correspond to the much less strongly developed "sphincter" fibres found by Böhmig in the pharynx of *Plagiostoma Lemani*; but the term sphincter, owing to their extent, is not applicable to them in the case of *Temnocephala.*

the character of unicellular digestive glands. In addition there are a few cells identical with the excretory cells.

In all essential respects all the Australasian species agree in the form and structure of the pharynx ; any differences that there exist relate only to relative size and relative degree of development of the various layers of muscle and of the unicellular glands.

If Weber's account of the pharynx of *T. Semperi* be correct, which I see no reason to doubt, we have here another feature in which that species diverges from the others in the direction of a greater simplicity of organisation. He describes the wall of the pharynx as consisting mainly of circular fibres, with sparsely developed radial fibres, in contrast to that of other Trematodes, and endeavours to account for this by the nature of the food. But a sucking action in the case of an animal immersed in water is as important in drawing whole prey into the mouth as in drawing in blood, epithelial detritus, etc. ; and it will be seen from the above description that the pharynx of *Temnocephala*, at least in the Australian species, belongs to the same type as those of *Polystomum*, *Calicotyle*, *Sphyranura*, and *Pseudocotyle*. *T. Jheringii* in this respect, as in a good many others, appears to approach nearer *T. Semperi*.

Brandes refers to the structure of the pharynx of *T. brevicornis*, and figures a section.* He recognises the anterior and posterior masses of transverse fibres, previously overlooked, and lays stress on their importance as corresponding with the sphincters of the pharynx in the *Rhabdocœla*. The muscular fibres he characterises as hollow—an appearance which, as I have elsewhere pointed out, is probably due to the condition of his material.

The pharynx of *Plagiostoma Lemani*, as described and figured by Böhmig,† approximates very closely to that of *Temnocephala*. So also does von Graff's "pharynx bulbosus rosulatus" of most Rhabdocœles, except that the direction of the layers is reversed, and that the thick anterior and posterior transverse bands are wanting.

Craspedella differs from *Temnocephala* in the rudimentary character of the pharynx.

Between the pharynx and the intestine, into the short passage which may be called œsophagus, there open the ducts of a large number of unicellular glands resembling those described in a number of other ectoparasitic Trematodes as salivary glands. Neighbouring cells are often coalescent: they have homogeneous protoplasm and oval nuclei ·0075 mm. in diameter.

* *Loc. cit.* p. 574, pl. XXII. fig. 20.
† *Loc. cit.* p. 414, and p. 219, fig. 8.

The intestine of *Temnocephala* may be described as a four-sided, dorsi-ventrally compressed sac—varying considerably in shape, like some of the other organs, with the state of extension or contraction of the body. In close contact with it dorsally, at the sides, and to a greater or less extent on the ventral surface, are the lobes of the vitelline glands. Behind it presents a deep concavity in which the receptaculum vitelli is situated.

The entire organ is invested with a thin layer of muscular fibres—a feature apparently only presented among monogenetic Trematodes by *Sphyranura*, though it occurs in many of the Rhabdocœles. The nature of this investment is not recognised by Weber, who calls it *tunica propria;* but it is unlikely that in this respect there is any difference between *T. Semperi* and the other species. Passing inwards from this there are, in all the species I have examined, with the exception of *T. Jheringii* and *Craspedella Spenceri*, a number of transverse bands of muscular fibres, which at regular intervals constrict the lumen of the intestine (Pl. XIV. figs. 1 and 2, and Pl. XV. fig. 1). These septa, as they may be called, are continued outwards at the sides also by irregular bands of fibres which are affixed to the basement-membrane of the integument. By means of these the cavity of the intestine is partly subdivided, so that it consists of a central space and a series of pouches or cœca, which, as they are continued completely round, may be described as annular.*

The main substance of the wall of the intestine, which is very thick, is composed of a greatly elongated epithelium. The cells of this epithelium are so loaded with granules that it is often quite impossible to make out their outlines: they are very long and very narrow and closely packed; in many cases they seem completely coalescent; near its base each has a nucleus; internally each ends in a rounded club-shaped extremity, on which I have never succeeded in determining the presence of cilia.

The substance of these cells is of an exceedingly fluid character: in the interior is an open reticulum of fine fibres. Numerous rounded or polygonal spaces occur; these contain a clear colourless fluid, and enclose in each case one, more rarely two, large, strongly-refracting granules, which appear yellowish by transmitted light, and sometimes have an appearance as if they were composed of concentric laminæ; these were observed to be undergoing brownian movements, showing that they lie quite free in the watery fluid of the vacuole; active Bacteria were observed in the interior of one or two of these vacuoles in some cases. There can be little doubt that these granules, which are most abundant near the inner surface of the epithelium, are of an

* I do not understand Braun when he says with regard to my previous account of the septa that "die als Beweis dienende Abbildung eines Längschnittes verdient einen solchen Glauben nicht, da offenbar nicht ein durch die Medianebene sondern seitlich davon gelangter Schnitt vorliegt" (*l.c.* p. 429). A median section was by no means necessary in order to prove the point.

excretory character. Unlike similar granules that occur in some Rhabdocœles* they are confined to the alimentary epithelium and do not extend to the parenchyma.

Between the ordinary epithelial cells there are narrow tubular cells with enlarged and rounded inner ends, full of granules, which become very darkly coloured with carmine or hæmatoxylin, but are transparent and colourless in the unstained condition. These cells frequently bifurcate. Their granular contents are probably of the nature of a digestive secretion. Similar cells—the so-called "Körnerkolben"—have been described by v. Graff and others as occurring among the epithelial cells of the intestine in some *Turbellaria;* and Kerbert† observed them also in a Digenetic Trematode.

IX.—THE EXCRETORY SYSTEM.

When I published my former account of *Temnocephala* the mode of opening of this system on the exterior by two dorsally and anteriorly placed apertures seemed quite exceptional among the Trematodes. It has since been shown, however, that this is not the case. A similar arrangement is found to prevail in *Polystomum, Diplozoon, Octobothrium, Sphyranura, Axine, Microcotyle, Gyrodactylus, Dactylogyrus, Pseudocotyle,* and *Tristomum* and other *Tristomidæ;* in fact, as pointed out by Braun,‡ the supposition that ventral openings occur was the result of an error. But in several other respects the excretory system of *Temnocephala* differs widely from that of other Trematodes—so far as known.

Each of the two excretory pores of *Temnocephala* and *Craspedella* leads into a thick-walled terminal vesicle or excretory sac (Pl. x. fig. 11), which is of pyriform shape, but somewhat bent on itself at the apex. The sac is contractile, the contractions being brought about by the agency of a complete layer of muscular fibres (fig. 13, *mu.*). Surrounding the orifice there is also a set of muscular fibres by means of which the aperture can be contracted or dilated. The wall of the sac is of protoplasmic material, having in the fresh state a yellowish colour; examined in sections (figs. 13 and 14) it proves to be finely fibrillated. In the wall of the main part of the sac there are no nuclei, but in the wall of the curved narrow apical portion is a large nucleus, and a second lies a little further on in the wall of the main canal. Those two nuclei were formerly supposed by me to be the nuclei of nerve-cells closely applied to the terminal vesicle. The re-examination of series of sections (Pl. x. fig. 14) has, however, shown me that this was an error, and that the nuclei in question—which are of exactly the same character as the nuclei of the excretory cells

* Böhmig, *l.c.* p. 239.

† "Beitrag. zur Kenntniss der Trematoden." 'Arch. f. Mikro. Anat.' XIX. p. 529 (1881).

‡ "Ueber die Lage des Excretionsporus bei den ectoparasitischen Trematoden." 'Zool. Anz.' XI. (1889), and "Ueber *Temnocephala.*" 'Centralbl. f. Bacteriologie u. Parasitenkunde,' VII. Bd. (1890).

to be presently described—are in the position indicated above.* The one is, then, the nucleus of a cell the body of which forms the wall of the excretory sac; it is the nucleus of a cell which is *perforated by* the excretory sac or terminal part of the excretory system of passages. The large size of the sac (about ·4mm in *Temnocephala fasciata* in the contracted state) might at first sight seem to stand in the way of looking at it as a single cell; but, as will be shown presently, there are other cells of comparable size connected with the excretory system. The second nucleus is the nucleus of an elongated cell which *is perforated by the main canal:* and as the wall of the canal and its branches is completely continuous we are justified in regarding this as a case like that of the unicellular glands described above, in which the cell is drawn out to a very great length. Only a very limited number of nuclei occur in the course of the main canals of *T. fasciata;* so that, so far as the main trunks are concerned, the latter seem to be perforations in a small number of greatly produced cells. Each tentacular vessel in *T. Dendyi* (Pl. x. figs. 17 and 18) also perforates a cell the substance of which is permeated by a plexus of capillaries; and in *T. fasciata* there are several nuclei in the wall of each of these tentacular branches. The excretory canals in *Temnocephala* are, in fact, intracellular as postulated by Lang for Trematodes in general; but in a considerable part at least of their length they are perforations in the substance of *only a limited number of greatly produced cells* (Pl. x. fig. 16) united together in the form of a narrow branching cylinder. This view of the matter may seem somewhat paradoxical at first sight; but to my mind the facts already described with those yet to be mentioned can bear no other interpretation.

Weber describes and figures the course of the principal canals as they are found in *T. Semperi;* and the differences between this and the Australian species are not of an important character. The general arrangement is as follows:—The main canal into which the sac leads soon bifurcates to form two trunks, from which large vessels pass backwards and forwards, giving off numerous branches. The anterior trunks are connected across the middle line by a transverse arch, from which are given off in front a series of large branches running along the axes of the tentacles. Similar transverse arches connect the posterior trunks. In the details of the branching and anastomosing of the canals there is a considerable amount of difference between the various species. The arrangement observed in *T. Novæ-zealandiæ* is shown in Plate XI. fig. 1.

The branches give origin to a system of canalicules or capillaries, superficial in position, of small calibre and thin walls, forming a plexus which is best developed

* It is rather remarkable that Wright and Macallum describe ganglion cells as applied to the excretory vesicles of *Sphyranura Osleri* (*l.c.* p. 20). It seems to me not improbable that they have fallen into the same error as myself. The explanation of my figure 9, Pl. XXI., with the nuclei external to the sac and the duct, is that what is represented is in reality merely the *lumen* of the sac and of the duct.

near the dorsal surface beneath the layers of muscle; many of the terminal branches enter the protoplasm of the large excretory cells to be presently described. They contain "Wimperflammen" in some parts at least,* but whether in the general course of the capillaries or in special dilatations has not been determined. Certain of the branches, however, have a very special mode of ending now to be described.

There enter the substance of the wall of each excretory sac (Pl. x. fig. 12) on the inner side a number of small canals which come off from the anterior main trunk. These branch through the protoplasmic substance of the wall of the sac, giving origin to a rich plexus of exceedingly fine capillary canals (about ·004 mm. in diameter), which do not appear to have any special walls. In the course of these capillaries and in slight terminal dilatations of side-branches are numerous "Wimperflammen" ·005 mm. in length. The latter are at all times difficult to see: the animal must be pretty strongly compressed in order to bring them into view, and after a few minutes of such compression their movements cease, and they are no longer to be distinguished. In many cases I have failed to see them altogether; in others only one or two came into view; only in a few rare instances have I succeeded in seeing a number of them in motion all at once, with that peculiar restricted undulating movement which once seen cannot be mistaken. In one case in *T. Dendyi* as many as twenty were seen in movement at once, and there are probably many more in each sac. In *T. Novæ-zealandiæ* they are still more numerous—about fifty being sometimes visible at once. In this species it was noticed that when the terminal sac was distended the flames in its walls did not appear to move. The general arrangement of these capillaries in the wall of the sac as seen in *T. Dendyi* is represented in fig. 12 of Plate x. In *T. minor* and *T. Novæ-zealandiæ* the arrangement is similar.

In sections of specimens prepared by Flemming's method and stained with alum-cochineal or hæmatoxylin this remarkable system of intracellular capillaries is readily traceable (Pl. x. figs. 13, 14 and 15), though it is a little difficult to be sure of the "Wimperflammen," which are always, as is generally recognised, difficult to make out—if at all recognisable—in sections.†

Other branches end in the substance of certain peculiar cells which may be called the *excretory cells*. The branches in question are sometimes of large size as compared with those that enter the substance of the wall of the terminal sac, with a comparatively thick protoplasmic wall, but in other cases are exceedingly fine capillaries. The excretory cells are very large—as much as ·15 mm. in diameter. Each has a

* I have found them in the tentacles, immediately in front of the brain, at the side of the excretory sac, a little distance in front of it, and in the neighbourhood of the ovary and receptaculum vitelli. Where flames were detected, no nuclei were ever observed in close proximity to them.

† The "vacuoles" in the protoplasmic wall of the terminal sac referred to by me in my earlier paper are really the larger of these canals, or rounded spaces which the latter give rise to when the sac becomes altered by too great compression or by the action of acids.

single nucleus, of a diameter of about ·023 mm., which when stained with hæmatoxylin shows a large spherical stained centre with a number of much smaller rounded bodies, also intensely stained, arranged round it in a single layer, and with a scanty intra-nuclear achromatin network, between the meshes of which and adhering to the threads are irregular minute particles which have the appearance of flocculent matter precipitated from a fluid. These cells are devoid of any enclosing membrane and, usually, though not invariably, have a number of processes. The canal breaks up on entering the cell into a number of capillary channels (Pl. XI. figs. 2 and 3) which ramify richly throughout the protoplasm in all directions. In other cases small vessels run round the periphery of the excretory cell and send minute capillary branches into its substance. I have not been able, after often-repeated and careful search, to find "Wimperflammen" in the course of these intracellular channels, and though, taking into account what has been described in regard to the terminal cell, it seemed not improbable *a priori* that those structures should be present, I think I have made fairly certain that they are not.

Cells in most respects similar to these, of similar size, with nuclei of precisely similar character, and with coarsely fibrous protoplasm having a radiate arrangement but apparently devoid of canals, are to be found here and there; a set of these always occurs, arranged with the greatest regularity, between the bases of the tentacles and the pharynx; they are frequently perforated by dorsi-ventral strands of the parenchyma muscle.

It will be seen from the above that the entire excretory system of *Temnocephala* (with the exception perhaps of some of the fine capillaries), is intracellular, and that the entire number of cells in the interior of which the system lies is very limited. A part at least of the system of larger trunks has a wall formed of a branched extension of the subterminal cell and of one or two others; a part doubtless is formed by extension of the renal cells; what share those cells severally take in forming the trunks could only be decided by a detailed investigation of the development of the system.

The remarkable result also follows that structures which appear to correspond to flame-cells of other flat-worms are not here of the character of cells at all—a large number of ciliary flames being present within the substance of a single large cell.

Another set of cells which are probably appended to the excretory system, though positive evidence of this is wanting, are much fewer in number than those just described, and usually of even larger size—as much as ·16 mm. in diameter, with nuclei about ·03 mm. They differ from the excretory cells in the effect of staining agents on their protoplasm, in the larger size of their nuclei, in the presence of a

definite fibrous investment, and in being perforated by numerous bands of parenchyma muscle. The protoplasm has a more or less radiate structure, and has very much the appearance of being permeated by narrow branching channels.

Cells similar to the excretory cells described above, but much smaller and devoid of canals, occur here and there, and have to be mentioned here as perhaps belonging to the same system.

It will be seen that there are several important lacunæ to be filled up in the above account of the excretory system of the *Temnocephaleæ*. The precise arrangement of the few "flames" that occur outside of the terminal sacs remains to be determined, and I am still uncertain if any of the capillaries end otherwise than by entering the substance of the excretory cells. Mature specimens are not favourable for the determination of such points, being too dense, and, in most cases, too strongly pigmented; and they are only likely to be cleared up by the examination with the best objectives of young specimens removed from the egg. The development of the system, I need hardly add, must be traced before some of its relations can be understood.

X.—THE NERVOUS SYSTEM.

The histological elements of the nervous system are the nerve-tubes and the bipolar and unipolar ganglion-cells. Preparations made by a great variety of methods have failed to throw further light on the structure of the nerve-tubes. They are cylindrical tubes, varying greatly in diameter—from ·005 mm. to ·02 mm. in *T. fasciata*, with a firm wall of what looks like condensed fibrous tissue. In the interior is a very finely reticulate matter which is only acted on, and then very slightly, by colouring fluids after all the other tissues have become intensely stained; from its tendency to shrink under the action of hardening agents this contained matter is evidently of a soft and more or less fluid character. Böhmig's* account of the minute structure of the nerve-tubes in the *Rhabdocœla*, with the contained bundle of parallel fibrils does not apply to *Temnocephala;* in the latter the fibrils, when distinguishable, appear as excessively fine threads which anastomose irregularly.

The unipolar nerve-cells occur only in the brain; the bipolar frequently elsewhere in the course of the peripheral nerves. Multipolar nerve-cells such as those described by Böhmig were not seen except in one doubtful case, in which a ganglion cell which had apparently three processes was observed in the wall of the pharynx.†

* *Loc. cit.* p. 257.

† The large multipolar cells described by Lang as occurring in *Tristomum* are, I think, the excretory cells.

The nerve-cells (Pl. XI. figs. 4-9) appear as swellings in the course or at the end of nerve-tubes. Each contains a spherical or subspherical nucleus, ·015 mm. in diameter in *T. fasciata.* This always contains a relatively small nucleolus in which all the chromatin appears to be condensed; and a delicate achromatin network with irregular collections of minute particles similar to those in the nuclei of the excretory cells. In the cytoplasm are numerous very fine fibrils mostly arranged concentrically around the nucleus, but some radiating outwards from it.

The brain (Pl. XI. figs. 5 to 9) is situated just in front of the pharynx, and not far from the dorsal surface of the body. It consists of a central fibrous mass and groups of ganglion-cells. When the former is looked at from above it appears squarish; but it is best described as a broad thick band (Pl. XI. fig. 5) which is transverse and horizontal in its middle part, but laterally bends downwards and backwards to the point where it passes into the posterior nerve-cords. It is the transverse part which gives the appearance of squareness.*

Weber† describes the brain in *T. Semperi* as consisting on each side of a ganglion, with a core of "Punkt-substanz" surrounded by fibres—the ganglia united by a commissure; but there is no division by a constriction into two lateral portions in any of the species I have examined.

The central part of the brain consists of a finely fibrous material, having the transverse commissural nerve-tubes closely applied to it, and sometimes traversing its substance, with a number of larger tubes and spaces containing matter similar to that which occurs in the interior of the nerve-tubes. On either side are two great groups of bipolar, with a few unipolar ganglion-cells; these are very numerous—some hundreds in number altogether—and present a totally different appearance from that represented by Weber. One of the groups of ganglion-cells is the root of the nerves that pass forwards; every nerve-fibre has near its origin a bipolar cell—one process being the nerve-fibre, the other passing into the central substance of the ganglion, through which it is frequently traceable. The other group is the root of the nerves that pass backwards; and the relations of the cells to the fibres are here the same. The commissural fibres also have ganglion-cells in their course.

In a series of horizontal sections, followed from the dorsal towards the ventral side, we first come, in the section passing through the middle of the eyes (Pl. XI. fig. 9), upon two symmetrically disposed groups of ganglion-cells situated behind the eyes, and separated from one another by a distinct interval. At a deeper level, but still not completely below the eyes, the position taken by the two groups of cells is

* Semper's figure and short account of the brain include some of the paired non-nervous cells situated in front of and behind it.

† *Loc cit.* p. 22.

occupied by a broad transverse band of fibrous material, through which are traceable numerous nerve-tubes; the nerve-cells are now collected into two groups, which are wide apart and external to the eyes. On a somewhat deeper plane the lateral groups of nerve-cells begin to be divisible into an anterior and a posterior set—the former connected with the anterior, the latter with the posterior, series of peripheral nerves. At a still lower level the ganglion-cells become fewer; and the fibrous band exhibits very large spaces and channels which are quite symmetrically disposed on either side of the middle line; here the central mass assumes an investment, apparently of the nature of parenchyma muscle, on its anterior and posterior surfaces; the spaces increase in size towards the ventral surface of the brain.

On carefully going over such series of sections and comparing them with longitudinal, vertical (Pl. XI. fig. 8), and transverse series, it becomes evident that the nerve-tubes which enter either side of the central fibrous mass in great measure coalesce to form the large symmetrically disposed spaces and channels which are filled with the same extremely delicate material that occupies the interior of the nerve tubes themselves. There are thus two entirely different elements to be distinguished in the "Punkt-substanz" of the brain-ganglion: (1) a tolerably dense reticulum of fibrous material, through which run many nerve-tubes; and (2) a series of channels of comparatively large size containing delicate, readily altered material similar to that which fills the nerve-tubes. The relative position and arrangement of these two elements are shown in fig. 8 of Pl. XI.

In the arrangement of the peripheral nerves of *Temnocephala* a remarkable feature is the large development of the nerve-cords which run forwards from the ganglion—this being co-ordinated with the presence of the tentacles, into the base of each of which a large nerve enters.*

Posteriorly there are given off three pairs of longitudinal cords—a dorsal, a dorsi-lateral and a ventral. The first of these, which is smaller than the others, is superficial in position, lying immediately underneath the longitudinal layer of muscle. The two cords leave the cerebral ganglion at its posterior and lateral angles, and run backwards along the dorsal aspect parallel with one another, connected here and there by transverse commissures. Externally branches are given off at tolerably regular intervals; these ramify and the ramifications anastomose, giving rise to a network of nerve-branches extending outwards to the lateral border. In *T. quadricornis*, if not in the others, there are occasional ganglion-cells in the course of these branches.

* Weber (l.c. p. 23) remarks on the large size of these cords as represented in my fig. 6 of pl. XX.; but, though the whole of that figure is diagrammatic and intended only to show the general relations of parts in the genus, there is little exaggeration in this respect.

The diagram of the arrangement of the dorsal nerve-cords and their branches given in my former paper (Pl. XXI. fig. 12) represents what is observable in *T. Novæ-zealandiæ.* In young specimens of *T. fasciata* recently hatched the course of these nerves is readily followed, and their arrangement, which is subject, as regards details, to considerable variation in different individuals, is represented in fig. 1 of Plate XII. In *T. quadricornis* the arrangement is, in all essential respects, the same. In a horizontal series of sections single fibres from the transverse branches are seen to be given off with considerable regularity in a vertical direction, so as to perforate the muscular layers, probably ending in the integument.

The second or *dorsi-lateral* pair of nerve-trunks, which are much larger than the dorsal, are situated much nearer the lateral border, and are more deeply placed, though much nearer the dorsal surface than the ventral, and just outside the vitelline glands and the testes. The third pair or *ventral* cords are the largest of the three. They curve round the pharynx and run along the ventral aspect in the angle between the testes externally and the intestines internally. Connecting the ventral and dorsi-lateral cords of the same side, and connecting the two ventral cords are numerous transverse commissures.

Only two of these three pairs of nerve-trunks, the dorsi-lateral and the ventral, were observed by Weber. He remarks on this point, "Was ich von den nach hinten laufenden Nervenstämmen sehe, ist mithin in vollständiger Harmonie mit Haswell's fig. 6 auf Taf. XX., passt aber nicht zu seiner Beschreibung." The figure to which he refers is a general diagram of the organisation of *Temnocephala,* and in this, for the sake of clearness, the dorsi-lateral cords are omitted.

The arrangement of the nerves, and in fact the entire structure of the nervous system of *Temnocephala,* conforms very closely to that of *Tristomum molæ* as described by Lang*—the chief difference consisting in the greater development of the nerve-cords that pass forwards from the ganglion. This arrangement of the principal nerve-trunks is, however, not confined to the ectoparasitic forms, a similar disposition being observable in some at least of the *Digenæa.*†

The system of visceral nerves which extend through the wall of the pharynx was previously overlooked. It forms a system of some little complexity, the general arrangement of which is represented in fig. 3 of Plate XII. In the course of some of the branches are bipolar ganglion-cells.

Eyes are absent in *T. Jheringii.* When present they have in all the species which I have examined the general structure which I have described as characterising

* "Ueber das Nervensystem der Trematoden," 'Mittheilungen a. d. Zool. Station zu Neapel,' II. Band.

† E. Gaffron "Zum Nervensystem der Trematoden." 'Zool. Anz.' VI. (1883).

those of *T. fasciata*. In this, as in several other particulars, the species described by Weber appears to be of simpler organisation: the eye in *T. Semperi* he describes as a mere spot of pigment lying directly on the ganglion and enclosing two or three spherical bodies, which may be of a refractive nature. In the Australian and New Zealand species (Pl. XI. figs. 6, 7 and 9, and Pl. XII. fig. 2) there is always a cup, deeper or shallower, of dense pigment *(p. c.)*, contained in which and projecting from whose mouth is a body of a light pink hue *(r. b.)*, which we may presume to be a refractive body. In the pigmented species the pigment-cup is completely continuous with the general pigment layers of the body. The contained body proves, when examined in sections, to consist of two distinct parts, differing in their appearance and in their affinity for staining agents. The one part *(c.)*, that which projects from the mouth of the cup, has the appearance of a nerve-cell closely applied to the mouth of the cup, and contains a nucleus. The other part, that which fills up the interior of the pigment-cup, is non-nucleated, and appears very minutely fibrillated; in some sections it presents the appearance of being partly divided in its deeper part into segments by means of a series of fissures. In *T. minor* (Plate XII. fig. 2) there projects through the aperture of the pigment-cup, round its margin, a circlet of short thick cylindrical (?) bodies continuous with the central substance in the cavity of the cup itself. Embedded in a mass of pigment which projects on the inner side of the pigment-cup there is in *T. fasciata* and *T. Dendyi* a spherical body, which in the fresh state appears very clear and glassy, and which does not readily colour with staining agents. It contains in its interior a large nucleus similar to that of one of the excretory cells. At the base of the cup are several nerve-cells *(n. c.)*, one short process of each of which enters the eye; while the other is continued into a nerve fibre which enters the brain, forming a short optic nerve.

Connected with the pigment-cup of the eye are bundles of fibres of the parenchyma muscle, which probably have the function of altering the position of the organ. Similar muscular strands have been described by Lang as connected with the eye in *Tristomum*.

XI.—MALE REPRODUCTIVE ORGANS.

The genital cloaca is a dorsi-ventrally compressed median cavity, opening by a small transverse slit-like aperture in the middle line of the ventral surface, a little distance in front of the sucker. It is lined by a continuation of the cuticle, epidermis and muscular layers of the general body wall. Into its interior on the left-hand side projects the cirrus, while on the opposite side is situated the female opening.

There are in all the species two pairs of testes, both laterally situated about midway between the dorsal and the ventral surfaces. Both testes are more or less oval in shape, with the long axes nearly parallel with the long axis of the body—the anterior somewhat more produced in *T. fasciata* and *T. minor* than in the rest. In the two last-named forms and in *T. Dendyi* both pairs are imperfectly divided externally by a series of slight constrictions or depressions corresponding to the series of transverse bands of the parenchyma muscle (*vide* Plate XIV. fig. 1). In the rest the testes are completely undivided. They are completely invested by a thin fibrous layer, which is, in great part at least, muscular. From the posterior end of the anterior testis there runs back a narrow efferent duct, which is continuous behind with the posterior testis. The true vas deferens arises from the posterior testis, and the spermatozoa from the anterior testis must pass through the substance of the posterior. Both efferent duct and vas deferens are lined by a very thin continuation of the fibrous investment of the glands.

The two vasa deferentia unite at a point to the left of the median line, in front of the genital opening into a large oval or pyriform sac—the vesicula seminalis (Pl. XII. fig. 7; Pl. XIII. fig. 21; Pl. XIV. fig. 2; and Pl. XV. figs. 1 and 3, *v. s.*). In the terminal part of the vas deferens, which is more dilated than the rest, there is a distinct protoplasmic layer, not divided into cells, and with nuclei at long intervals, internal to the fibrous investment, and both those layers are continued in the wall of the vesicula seminalis. The lumen of the vesicula seminalis is nearly always full of spermatozoa, which exhibit slow, coiling, streaming movements.

In certain of the species—*T. minor*, *T. Dendyi*, *T. comes*, *T. Semperi*—there is on the left side of the seminal vesicle opposite the base of the cirrus a coecal pouch (*e. s.*), which, in the Australian forms mentioned, is of considerable size, club-shaped, somewhat curved. In *T. fasciata* it is scarcely constricted off from the bulb-like base of the cirrus. In *T. Semperi* it is described and figured by Weber* as a short rounded sac. Weber describes it as "gland-like," but the structure of its wall is precisely the same as in the case of the vesicula seminalis—with an external muscular investment and an internal protoplasmic layer, without cell-outlines, and with a very small number of prominent nuclei. It usually contains a small number of actively-moving spermatozoa; and as the contraction of its walls was observed repeatedly to be followed by the protrusion of the penis and sometimes by the discharge of seminal matter from the extremity of the latter, it may be most appropriately named *ejaculatory sac*.

The cirrus, or penis, is a tubular organ, continuous with the ejaculatory sac and vesicula seminalis. It lies always on the left side and is directed obliquely inwards

* Weber, *l.c.* Taf. I. fig. 1, p. 13. Semper gives a similar account of it and terms it prostate.

towards the genital cloaca, into which it projects. In shape it varies very much in the various species, but in all it is wider—sometimes very much wider—at the proximal than at the distal end, and it is invariably armed at the extremity (except in *T. Engæi*) with a number of sharp chitinous spines. The organ is supported in the greater part of its length by a firm chitinous piece, which has the form just mentioned—tubular, but much wider proximally than distally. Lining this internally is a protoplasmic layer, continuous with that of the vesicula seminalis and of precisely similar character, though somewhat thicker. Closely investing the chitinous piece externally is a layer of muscular fibres, consisting of two strata, an external longitudinal and an internal circular, continuous with the muscular investment of the vesicula seminalis and ejaculatory sac. A short terminal part of the cirrus differs from the rest of the organ in having a flexible wall, so that it can be invaginated and evaginated; this may be termed the introvert of the cirrus. This is continuous with the wall of the cirrus sac; internally it bears a number of pointed chitinous hooks or spines, the size, form and arrangement of which vary with the species. In certain of the species there is internal to those a single large median spine, perforated at its extremity (*T. Dendyi*, Pl. XII. figs. 7 and 11), or a group of large, solid, curved and pointed spines (*T. quadricornis*, Pl. XII. fig. 10). These are terminal when the cirrus is protruded; and while the smaller spines would appear to have the function of fixing the end of the evaginated cirrus during copulation, the larger spines seem adapted to effect perforation, and perhaps enable the cirrus to be used as a weapon.

Connected with the male reproductive apparatus are a number of glands (Pl. XIV. fig. 1, and Pl. XV. fig. 1, *pr.*), the secretion of which contains minute spherical, highly-refracting particles, about ·0014 mm. in diameter in *T. fasciata*, of a light yellow colour, each enclosed in a spherule of clear uncolourable matter. The cells secreting these are closely associated with the tentacular and acetabular glands, but are readily distinguishable from them, not only by the nature of the secretion, but also by the fact that several cells always completely coalesce to form a pluricellular gland with a single duct. They are mainly to be found in two groups on each side—one situated between the two testes, the other behind the posterior testis; but they extend as far forwards as the excretory vesicle. These glands (Pl. XII. fig. 4) are usually about ·25 to ·3 mm. in long diameter in *T. fasciata*, each consisting of several cells, the boundaries of which have completely disappeared; the nuclei are about ·014 mm. in diameter and are similar in character to those of the integumentary glands, but usually somewhat smaller and with a thinner nuclear membrane. The ducts (Pl. XII. figs. 5 and 6) have very thin transparent walls, and can only be traced by the granules which they contain; they frequently branch and anastomose. Two main strands of these ducts—an anterior and a posterior—unite on each side near the point where the vas

deferens leaves the posterior testis. From this point they run nearly transversely, close to the vas deferens, until they reach the dilated bulb of the cirrus, into which they open. In *T. Dendyi* the strands of ducts combine as they near the base of the cirrus and end in a dilatation (Pl. XII. fig. 7, *l. g. n.* and *r. g. r.*), in which the rounded particles become aggregated together into irregular clumps. In the others the aggregation appears to take place in the interior of the bulb of the cirrus itself.

In the Rhabdocœles glands of this kind (the so-called "Körnerdrüsen," or "prostate glands") are of general occurrence, and v. Graff's account of them in that group would apply fairly well to *Temnocephala.* In certain Trematodes similar glands have also been found. Saint Rémy* describes them as occurring in the *Tristomidæ.* and the *Udonellidæ*:—"Chez les Tristomides et les Udonellides (et aussi chez Calicotyle d'après Wierzejsky) il existe des glandes spéciales sécrétant un liquide destiné à se mêler aux spermatozoïdes : dans ces deux familles ces glandes prostatiques déversent leur produit dans un réservoir communiquant avec le canal ejecteur (vesicule prostatique)." But the position and histological structure of the glands are not described.

XII.—THE SPERMATOGENESIS.

The spermatogenesis was studied in specimens treated by a variety of different methods. The best results were got by treating fresh specimens with methyl green; and by sections and teased preparations fixed by Flemming's method and stained with alum-cochineal. The former method was found very useful for other elements as well—the mode of procedure being as follows:—A live specimen was placed on a slide with the ventral surface upwards and covered with a cover glass so as to be slightly compressed. Watery solution of methyl green containing a little acetic acid was run in, allowed to act for an hour or more, and then washed out with water acidulated with acetic acid. A slight compression might then be required in order to cause the discharge of the contents of the testes. Good results were also obtained by staining hardened specimens with picrocarmine and teasing out in dilute glycerine.

The mode of development of the spermatozoa differs somewhat from what is observable in other Trematodes. In sexually immature individuals the testis consists of a mass of cells about ·015 mm. in diameter (Pl. XIII. fig. 1) with large nuclei with a dense network of chromatin and two small nucleoli, and with a comparatively small amount of cytoplasm. In the mature testis spherical or sub-spherical masses of cells, about

* Comptes Rendus, T. CXVII. (1891).

·04 in diameter in *T. fasciata,* derived from these mother cells (Pl. XIII. fig. 2) are to be found here and there scattered through the substance of the testis among the developing spermatozoa. By successive divisions accompanied by mitosis these give rise to large numbers of cells in which in successive stages the nuclei become reduced and the cytoplasm increases somewhat in relative amount. A stage in this process of division is represented in fig. 3. Except in the earliest stages there is no central connecting mass or cytophore. This absence of a distinct cytophore agrees with the results of Monticelli's observations on the spermatogenesis of Trematodes in general. ("Della spermatogenesi nei Trematodi," 'Bolletino della Societa di Naturalisti in Napoli,' Serie 1, Anno 5°, Vol. 5°, 1891, fasc. 2°.) Finally the stage represented in fig. 4 is attained in which the *Spermatidia* have become formed. Each of those, about ·01 mm. in diameter, has a small spherical nucleus (·003 mm. in diameter) of very dense, almost homogeneous, appearance, embedded in a very finely fibrillated cytoplasm, the whole having a somewhat irregular (usually more or less pyramidal) shape. In the next stage the nucleus of the cell becomes approximated towards one side of the cell, and develops a process which projects freely from the surface. This process gradually increases in length (figs. 5 to 9) until the whole nucleus assumes the form of a slightly curved, pointed rod with its base embedded in the mass of cytoplasm. It then becomes drawn out more and more (figs. 10 and 11), and at the same time somewhat bent so as to resemble a drawn-out letter S. One end of it—that embedded in the cytoplasm—has from the first been thicker than the other, and later on presents a distinct rounded swelling, the remainder gradually becoming more and more attenuated and increasing greatly in length. The swelling gives rise to the head of the spermatozoon. As this approaches maturity the contained chromatin comes to be arranged in the form of a symmetrically folded thread enclosed in a delicate membrane and continuous with the axis of the tail of the spermatozoon. At the same time there are developed from the posterior aspect of the head a pair of extremely long and slender vibratile cilia by whose vibrations the principal movements, if not all the movements, of the spermatozoon are brought about. The tail of the ripe spermatozoon is no less than ·2 mm. in length in *T. fasciata* and about the same in *T. minor;* the head 0·005 in diameter; the cilia ·015 mm. in length. In *T. Dendyi* the length (about ·7 mm.) is even greater—about a sixth or so of the total length of the animal! The shape of the head varies considerably; normally it is rounded, but it is often found to have an elongate form. In *T. Dendyi* the tail, excessively fine at the head end, gradually thickens towards the opposite extremity. At this end there is frequently a thin membrane-like expansion or a rounded, finely granular mass, in which the extremity of the tail is embedded; this becomes absorbed when the spermatozoon is quite mature. Running through the thicker part of the tail is a fine spiral line which appears to be formed by the spiral twisting of the delicate axial rod of nuclear material.

From the mode of development described above it follows that not only is the chromatin of the head of the spermatozoon derived from the nucleus, but also an axial fibre in the tail. A somewhat similar elongation of the nucleus is described by Jensen as taking place in *Plagiostoma vittatum.**

In the main features of their spermatogenesis there appears to be a general agreement between the Monogenetic Trematodes and the Rhabdocœles; and in these main features *Temnocephala* agrees with both. In all a rounded mass of cells—sperm-morula, or spermatogemma—is formed by mitotic division of the primitive cell. In some cases—*Plagiostomidæ* and some *Monogenæa*—these are connected with a central nucleated or non-nucleated mass or cytophore; in other cases this is absent, and the mass of cells contains a central space. In each of these cells—spermatocytes becoming spermatidia—it is the nucleus that plays the important rôle in the formation of the spermatozoon—the cytoplasm forming a thin investment, together with any appendages that may be present. The precise way in which the nucleus becomes modified to form the main part of the spermatozoon varies, however, very widely; and its history as we trace it in *Temnocephala* is highly characteristic, and differs considerably from anything that has been observed in either group.†

XIII.—Female Reproductive Organs.

These consist of ovary, receptaculum seminis (or, better, receptaculum vitelli), oviduct, uterus, vagina, vitelline and shell-glands, together with the unicellular glands already described as opening on the ventral surface around the genital opening.

The *ovary* (Pl. XIV. fig. 2, *ov.*; Pl. XV. figs. 1 and 2, *o.*)‡ is an oval body about ·15 to ·25 mm. in length, situated on the right of the median line, with its long axis directed obliquely. It consists of a solid mass of ova enclosed in a capsule of muscular fibres, the ova towards the right-hand end being small, polygonal and immature, those at the left extremity being fully mature. Each ovum, with the exception of those at the right end, is a narrow pyramid about ·083 mm. in length, passing transversely through the entire thickness of the ovary. The protoplasm contains a few spherical brightly refracting particles and a large nucleus, in which, in the living condition, streaming movements were observed to take place.

* "Recherches sur la Spermatogenèse." 'Arch. de Biologie,' IV. (1883).

† *Vide* v. Graff, *l.c.* p. 156; Böhmig, *l.c.* p. 286; Wright and Macallum, *l.c.* p. 38; Braun, *l.c.* p. 470; Jensen, "Recherches sur la Spermatogenèse," 'Arch de Biol.' IV. (1883); Monticelli, "Della Spermatogenesi nei Trematodi," 'Bolletino della Società di Naturalisti in Napoli,' Vol. 5° (1891).

‡ See also former paper, Pl. XXII. fig. 11.

Max Weber's account of the ovary in *T. Semperi* differs considerably from the above. He speaks of it as spherical, and describes and figures the ova as polygonal in shape. In these respects his species would seem to differ not only from all the Australian and New Zealand species, but also from that from Brazil, so near an ally of *T. Semperi* in other respects.

The *oviduct** is a rather narrow, curved tube leading from the ovary and receptaculum vitelli to the uterus. Its walls are muscular, containing an external circular and an internal longitudinal layer of muscular fibres. The lumen is lined by a non-nucleated layer of a material which is probably protoplasmic.

The sac formerly called by me *receptaculum seminis* (*r. v.*), and similarly named by Weber, is a median more or less ovoid or ellispsoidal sac, which is situated in the middle line in a deep bay in the posterior wall of the intestine. It varies immensely in size, according to circumstances. When not greatly distended, it has a tolerably thick protoplasmic investment of a granular character, exactly similar to the corresponding layer in the vesicula seminalis, with a small number of large nuclei. This is clothed externally with a thin layer of muscular fibres. When the sac is distended the wall becomes relatively thin.

As to the function of this receptacle; I had noticed spermatozoa in it in living specimens; and finding it in sections full of granular matter, I supposed this to be a mass of altered spermatozoa, and decribed the sac in my former paper as always full of spermatozoa. An examination of living specimens of the more transparent species during the period of sexual activity has, however, since shown me that this sac is really a yolk receptacle. Towards the period when a ripe ovum is to be discharged, the receptacle becomes filled with yolk matter, which greatly distends it, until it assumes nearly the size of the mature egg. Surplus spermatozoa are to be found mixed with this mass, probably together with surplus prostate secretion.

The uterus (ootype) *(ut.)* resembles the oviduct in structure, but is wider and has thicker walls. When it contains an egg it becomes enormously distended and the wall becomes thinned out. Into its interior open the ducts of the shell-glands.† The latter are unicellular glands of large size and irregular shape, situated around the uterus, each with a single large nucleus, and with a duct which is simply a long and narrow process of the cell terminating by perforating the wall of the uterus, where it presents a little vesicular enlargement acting doubtless as a receptacle for the secretion. A few of the shell-glands open into the distal part of the oviduct.

* See former paper, Pl. XXII. fig. 12.
† Former paper, Pl. XXII. fig. 13.

The vagina in *Temnocephala* is simply the passage leading from the ootype to the genital cloaca, by which the egg passes to the exterior, and into which, probably, the cirrus is received in copulation. In general its walls, though less muscular, resemble those of the uterus ; but in the New Zealand species (Pl. XIV. fig. 3) the structure is very remarkably modified. Here the vagina is a rounded muscular organ of relatively large size, forming, next to the cirrus, the most conspicuous part of the reproductive apparatus. Its walls consist of two great masses of muscular fibres, and on its inner surface are a great number of larger and smaller pointed chitinous teeth.

Unless *T. Semperi* is very unlike the Australian forms, Max Weber has fallen into an error in confounding together the ootype and the genital cloaca, and describing and figuring them as one cavity.* He has therefore interpreted wrongly the position of the shell-glands and their ducts. He says (p. 16)—"Schliesslich geht der Oviduct in den Uterus über, nachdem er sich vorher mit dem Cirrusbeutel vereinigt hat, der schräg in ihn ausmündet. Obwohl wir es mithin von jetzt ab mit einer Geschlechtskloake zu thun haben, durch die der Cirrus sowohl nach aussen gebracht als auch die Eier abgeführt werden müssen, möchte ich dennoch einen in die Quere erweiterten Raum, der kurz vor dem Genitalporus—der Ausmündung der Geschlechtskloake—liegt, Uterus nennen."

A number of the unicellular glands open on the surface immediately around the genital opening as already described. The ducts of these glands are not always distinguishable, as they are not readily to be seen unless the secretion is passing through them ; when this is the case they become extremely conspicuous in sections, being very numerous, situated close together, and presenting here and there little dilatations. It is probable that these glands have the function of secreting the viscid material by means of which the eggs after they are discharged are affixed together and to the surface of the Crustacean. Weber ascribes this function to a group of strings of cells opening immediately round the genital opening. There are no such structures in the Australian species.

The vitelline glands (Pl. XV. fig. 2, *v.*) attain a high grade of development in the *Temnocephaleæ.* They are closely adherent to the intestine, and cover nearly the whole of its dorsal surface, extending round the margins to encroach more or less on the ventral surface also. They consist of a series of narrow lobes, which anastomose occasionally so as to form an irregular network. In certain of the Australian species the lobes are arranged in irregular transverse lines following the divisions of the intestine, and thus presenting a rudimentary metameric arrangement. In longitudinal sections it is found that the muscular septa of the intestine pass outwards

* *Loc. cit.* p. 16 : Tab. I. fig. 1, and III. fig. 11. The same error, if it be an error and not a specific difference, is committed by Semper.

between these transverse lobes of the vitelline gland, separating them from one another with some degree of regularity. In *T. Semperi*, *T. Jheringii* and certain of the others this disposition, in accordance with the absence of the rudimentary septa, is not observable—the arrangement being quite irregular. On either side there is given off behind a thin-walled duct which runs inwards and backwards and eventually opens with its fellow into the oviduct close to the ovary and receptaculum vitelli.

As regards the minute structure: the lobes consist of large irregular cells with a tendency to a radial arrangement round the axis of the lobe. The protoplasm of the cells contains large granules. Frequently spaces appear between the adjacent cells, sometimes uniting to form a central cavity: these are irregular and are apparently formed by the breaking down of portions of the cells to form the secretion, the particles of which find their way, apparently, through these irregular spaces to reach the duct.

XIV.—Reproduction.

Self-impregnation is quite possible in *Temnocephala*. The cirrus is capable of being protruded far enough to penetrate into the uterus. The elaborate arrangement of spines which, inverted when the cirrus is at rest, bristle outwards from the end of the organ when it is protruded, obviously subserve copulation; but their great development in some of the species would seem rather to indicate cross- than self-fertilisation, since in the latter process they would not appear to be necessary. Telling still more strongly in favour of the view that cross-fertilisation takes place, is the presence in *T. Novæ-zealandiæ* of the remarkably powerful muscular vagina with its formidable array of teeth already described—a structure which can only have been developed with a view to retaining the cirrus of another individual until the spermatozoa had been discharged. In two instances I have found on examining series of sections of *T. Dendyi* that the specimen had been killed with the penis protruded through the genital aperture.* The preponderance of evidence would thus seem to be in favour of the occurrence of cross-fertilisation.

During the period of sexual activity large quantities of spermatozoa are developed in the testes, and are constantly passing along the vasa deferentia. They accumulate in the sperm-sac, which they greatly distend, and in the interior of which they circulate with slow streaming movements. A few at a time pass into the ejaculatory sac, where they become very active. The contraction of the ejaculatory sac is always followed by the protrusion, to a greater or less extent, of the cirrus, accompanied

* One of these is figured in fig. 7 of Plate XII. It may, however, have been in the act of being used as a weapon.

sometimes by discharge of spermatozoa and of the secretion of the "prostate" glands. I have never observed the act of copulation; but I have found in many specimens the uterus and oviduct to contain actively-moving spermatozoa; in some of those the uterus and oviduct were undergoing strong peristaltic contractions, tending to drive the spermatozoa forward. In such specimens, before an ovum has become discharged from the ovary and impregnated, the large sac usually termed *receptaculum seminis* is greatly distended with a mass of yellowish semi-fluid material. This consists mainly of the secretion of the yolk glands, but in the midst of it may be seen here and there movements indicating the presence of spermatozoa; apparently the overplus of spermatozoa, and very possibly that of the secretion of the prostate glands, forms a contribution to the accumulating mass of yolk. The so-called *receptaculum seminis* is thus more correctly to be termed *receptaculum vitelli.* When it is full its contents form a bulk the size of the uterine egg. In the next stages which I have observed this mass of yolk has become transferred to the uterus enclosing the impregnated ovum, which has meantime become discharged from the ovary—the *receptaculum vitelli* in such a specimen being contracted and empty. The mass of yolk, with the impregnated ovum, is of great relative size and greatly distends the uterus, displacing the neighbouring parts to a considerable extent. Here it becomes enclosed in a chitinoid shell.

Considerable variation occurs in the form and mode of attachment of the eggs in the various species. In *T. Novæ-zealandiæ* the somewhat pear-shaped eggs are attached by a short stalk connected with the narrower end, and when the embryo is mature the shell is ruptured by an annular dehiscence, so that a sort of lid is separated off and a goblet-shaped body remains attached to the crayfish. The same holds good of *T. minor.* In *T. fasciata* numbers of the oval eggs adhere together and to the surface of the crayfish by means of a layer of hardened secretion in which they are embedded; they lie flat on the surface, and on one side about the middle there is a short, slender stalk, which, however, does not serve for attachment. *T. quadricornis* presents a similar arrangement; the egg is much broader at one end than at the other, and towards the end is a rudimentary stalk. In *T. Semperi* there is only a slight rudiment of a stalk, and the eggs are cemented singly to the surface by one side.

Monticelli* describes in a species of *Temnocephala* which he regards, though he does not give his reasons for the determination, as *T. chilensis*, a very remarkable arrangement of the ova. They are pear-shaped, and a slender, flexible stalk of varying length connects them together two and two by the narrow ends; an operculum was not observed.

* "Breve nota sulle uova e sugli embrioni della *Temnocephala chilensis* Bl." 'Atti della Società Italiana di scienze naturali,' Vol. XXXII. 1889.

XV.—SYSTEMATIC ACCOUNT OF THE GENERA AND SPECIES.

Family TEMNOCEPHALEÆ.

In order to include the new genus *Craspedella* it will be necessary to alter still further Braun's modification* of my original diagnosis of the family.†

Monogenetic Trematodes (?) with dorsi-ventrally compressed body provided in front with four to twelve long, slender tentacles. No anterior sucker, but a large posterior one, devoid of hooks or marginal membrane and only exceptionally distinctly radiated. The integument consists of distinct cuticular and epidermal layers, with a basement-membrane. The epidermis is nucleated, but not divided into cells; in some cases it is ciliated. In most instances there is below the basement-membrane more or less pigment. Mouth situated some little distance behind the anterior end of the animal or the bases of the tentacles; a powerful spheroidal muscular pharynx in *Temnocephala* but not in *Craspedella;* the intestine unbranched, but in most of the species constricted at regular intervals by a series of imperfect septa. A pair of contractile excretory sacs with dorsal and anterior openings. Eyes usually, though not invariably, present. A single genital opening situated near the sucker; a genital cloaca into the cavity of which the protrusible cirrus projects and into which opens also the efferent duct of the uterus (here called vagina), which sometimes contains chitinous teeth. Ovary oval, elliptical, or spherical; a large receptaculum seminis or receptaculum vitelli; vitelline glands consisting of numerous lobes extending over the dorsal and lateral walls of the intestine. Two pairs of compact testes; a chitinous cirrus armed with spines at the extremity. Eggs with stalk-like appendages, by means of which they are sometimes attached; dehiscing sometimes by the separating off of an operculum-like part of the egg-membrane.

Genus TEMNOCEPHALA, Blanchard.

A number (four to twelve) of slender tentacles confined to the anterior extremity of the body. A large muscular pharynx. No posterior fringes or papillæ.

* L.c. p. 524.
† L.c. p. 299.

1. TEMNOCEPHALA FASCIATA. Plate X. figs. 1-3, 5 and 6, 13-16; Plate XI. figs. 2-4, 8 and 9; Plate XII. figs. 1, 4-6; Plate XIII. figs. 12-14; and Plate XIV. fig. 1.

Temnocephala fasciata, Haswell, l.c. p. 284, pl. xx. figs. 1 and 2.

This is one of the largest forms, attaining sometimes, when extended, a length of more than half an inch. It is also one of the most highly organised.

The body is strongly pigmented on both dorsal and ventral surfaces, the former being much the darker. The principal layer of pigment is situated below the basement-membrane of the integument, and superficial to the layer of longitudinal muscular fibres, and is arranged in an exceedingly fine and close network; but pigment also occurs on a deeper plane, internal to the longitudinal muscular layer. There are five subequal slender tentacles. The intestine presents a considerable number of constrictions with transverse muscular bands ("septa"). The testes are somewhat oval in shape, the anterior situated nearly opposite the middle of the intestine, the posterior nearly opposite the genital opening. The cirrus is strongly curved, and has a very definite introvert, which is considerably thicker than the part of the cirrus immediately preceding it; it contains a large number of close-set, stout, pointed spines. The vitelline glands spread over the dorsal surface of the intestine and extend also some distance on the ventral surface; their lobes have a tendency to become arranged in transverse rows. There are no teeth in the vagina.

Temnocephala fasciata occurs on the surface of the widely-distributed *Astacopsis serratus*, the largest of the Australian crayfishes; and I have obtained specimens of the parasite from various parts of the Blue Mountains, as well as from streams in the coastal districts from the Richmond River in the north to the Yarra in the south. I have never noticed a live specimen of the crayfish, small or large, recently removed from the water that did not harbour more or fewer specimens of *T. fasciata*. Usually there are many dozens on each crayfish. The specimens of *Astacopsis serratus* from different localities differ a good deal as regards colouration and other minor points; but except as regards slight differences in the arrangement of the lighter and darker zones, which does not always conform to the description previously given by me, the *Temnocephalæ* present little appearance of variation.

Together with *Temnocephala fasciata*, and closely resembling the young of that species, were found two examples of a distinct form. They were both very small, only about 2 mm. in length, but were in a much more advanced stage of development than are the young of *T. fasciata* when of that size. In the latter the reproductive organs are entirely undeveloped. In the form under consideration, though there were no fully developed spermatozoa and the ovary was not seen, the male reproductive ducts with the vesicula seminalis and cirrus were fully formed, as were

the oviduct and yolk reservoir. The cirrus (Plate XIII. fig. 14) was entirely unlike that of *T. fasciata*, closely resembling that of the New Zealand species, only slightly curved, and with but a small introvert with exceedingly fine spines. The oviduct (vagina) had a zone or circlet of what appeared like rudimentary chitinous teeth.

2. TEMNOCEPHALA COMES. Plate XIII. figs. 15 and 16.

This species is a good deal smaller than *T. fasciata*, and is at once distinguishable from it by the absence of pigment, giving the animal an opaque white appearance, and by the invariable presence of six tentacles. The eyes also are much smaller than in *T. fasciata*, but in most other external features there is a tolerably close resemblance. In the internal organisation the chief difference is in the form of the introvert of the cirrus, as represented in figures 15 and 16. Both pairs of testes, which are small and rounded, are situated far back—one close to the posterior border of the intestine, the other behind the latter altogether. This species lives side by side with *T. fasciata* on the surface of *Astacopsis serratus*, but usually about the bases of the appendages and in the crevices. When I wrote my previous account of Temnocephala, I took those for the young of *T. fasciata*, and a batch of their eggs containing six-tentacled embryos for the eggs of the latter species; I was therefore led to the conclusion that the latter form had six tentacles when it emerged from the egg and was devoid of pigment, whereas in the species in question the pigment appears before the young Trematode leaves the egg, and there are from the first only five tentacles.

The eggs of the present species are of similar shape to those of *T. fasciata* and little, if at all, smaller; in several cases an egg was found *in utero*. A good many specimens were found to be abnormal in the structure of the reproductive organs, and many of them had parasitic Nematodes or their eggs or embryos lodged in the testes, the receptaculum seminis or the uterus; one was found without any eyes, in another the eye was only developed on one side. In most of the larger forms the alimentary canal contained a red granular matter; in the smaller individuals the contents were simply mud, with numerous sand-grains, diatom-valves, &c.; and in none were there found the entire small Arthropods that form the principal food of *T. fasciata* and *T. minor*.

3. TEMNOCEPHALA MINOR. Plate XII. figs. 2, 8 and 9; Plate XV. fig 1.

Temnocephala minor, Haswell, l.c., p. 284, pl. XX. figs. 4 and 5.

This is a comparatively small species, being rarely, when fully extended, more than a fifth of an inch in length, and being relatively slender. There are, as in *T. fasciata*, five subequal tentacles. The general colour is grey. The pigment, which is almost entirely confined to the dorsal surface, is disposed in a network of narrow lines with

meshes of irregular shape, not covering the whole surface, but leaving considerable spaces entirely free. The pigment-cups of the eyes appear as a special condensation of the pigment, continuous with the general network. A noteworthy feature of the integument already alluded to is the presence of vibratile cilia in the region behind the tentacles. The alimentary canal has seven or eight well-marked constrictions, which correspond with incomplete muscular septa. The anterior testis extends a little further forward than the middle of the intestine. The posterior testis has its anterior end considerably in front of the posterior end of the latter; its posterior end is a little behind the genital aperture.* Both testes are very distinctly divided laterally into lobules by transverse incisions. There is a well-developed, narrow, curved ejaculatory sac, which is sometimes as long as the cirrus. The latter (Pl. XII. fig. 8) is very gently curved, wide at the base, narrowing distally, with a very definite terminal segment or introvert, wider than the part of the organ which immediately precedes it, and containing on either side a large number of fine spines†. There are no teeth in the vagina.

This species occurs on the surface of the widely-distributed small Australian crayfish—*Astacopsis bicarinatus*—of which it is a constant companion. Its habits are similar to those of *T. fasciata.* The pear-shaped eggs, supported on short stalks, are attached most commonly to the sternal surfaces of the abdominal segments of the crayfish, sometimes to the lateral parts of the cephalothorax, or the bases of the antennules, eye-stalks and antennæ.

4. TEMNOCEPHALA DENDYI. Plate X. figs. 8, 12, 17 and 18; Plate XI. figs. 5 and 6; Plate XII. figs. 7 and 11; Plate XIII. fig. 1.

This species is usually somewhat larger than *T. minor* and rather broader in proportion to its length (about ·5 c.m.). It is entirely devoid of pigment, with the exception of a few scattered granules in the eyes; the eyes are smaller than in *T. minor*, with shallower pigment-cups, the openings of which are directed outwards. In other respects the general external appearance is similar to that of the latter species, and there are five tentacles. In internal structure also there is a very considerable resemblance. There are ten to twelve constrictions in the intestine. The chief internal difference is in the male reproductive apparatus. The posterior testis is situated much further back than in *T. minor*, its anterior border being about on a line with the generative opening. Both testes are lobed. The vesicula seminalis is much narrower. But the most important difference is in the cirrus,

* These relations vary a good deal, naturally, according to the condition of the specimen.

† The Nos. of figs. 9 and 10 of Pl. XXII. in my former paper have been inverted; fig. 10 is intended to represent the cirrus of *T. minor*, but none of the cirri, except that of *T. fasciata*, are adequately represented, the arrangement of the spines not having been understood.

which is relatively longer and narrower than in *T. minor*, wants the terminal dilatation, and is provided with a median sharp-pointed spine, usually retracted, so as to be contained within the lumen of the introvert, but everted when the cirrus is protruded. In addition the introvert is armed with a very large number of small spinules, which bristle out when the terminal spine is protruded. The lobes of the vitelline glands are comparatively few and large. The ducts of the prostate glands are very large, and are dilated where they open into the basal bulb of the penis, so as to form a sort of reservoir for the secretion.

This species occurs along with *T. minor* on the surface of *Astacopsis bicarinatus*, both in New South Wales and Victoria. The differences mentioned above, though not very extreme, were found quite constant throughout the large number of specimens examined. The two species differ widely also, as already mentioned, in the nature of the eggs and the mode of their attachment. They are not stalked in *T. Dendyi* and are attached most commonly to the inner wall of the branchial chambers, sometimes to the bases of the gills.

T. Dendyi is often found in considerable numbers in the branchial cavities of the crayfish.

5. TEMNOCEPHALA QUADRICORNIS. Plate XII. fig. 10, and Plate XIV. fig. 4.

Temnocephala quadricornis, Haswell, l.c. p. 284, pl. XX. fig. 3.

This, the only Tasmanian species I have seen, is at least equal in size to *T. fasciata.* It is of a dark brown colour, finely mottled. Its most striking external feature is the presence of only four tentacles, the median one (or two) present in the other species being replaced by a short, broad dorsi-ventrally compressed lobe with a convex anterior border. The sucker is very distinctly radiated, and is relatively rather larger than in *T. fasciata.* The internal organisation is similar to that of the last-named species, but there are fewer constrictions in the intestine (seven or eight); both pairs of testes are situated further back—the anterior, which is round and undivided, being behind the middle of the intestine, and the posterior, which is rather larger and bilobed, being situated somewhat behind the genital cloaca; the introvert of the cirrus is smaller, and its spines, instead of being nearly uniform in size and shape or gradually increasing in length from without inwards, are arranged in three distinct sets: a set of many short acute spines, which closely beset the outer part and bristle outwards when it is everted; a small number of blade-like, pointed spines a good many times the length of those of the first set; and a limited number of slender spines intermediate in length between those of the first two sets and slightly hooked at the ends. The last two sets must be extended like the median spine of *T. Dendyi* when the cirrus is fully protruded. *T. quadricornis* occurs on the surface

of the large crayfish *(Astacopsis Franklinii)* that frequents the northern rivers of Tasmania.

My specimens of *T. quadricornis* have not been very well preserved for minute investigation; but they show some marked peculiarities in the histology when compared with the other species. One remarkable feature is the large size of the nuclei, and their possession of closely coiled chromatin threads, unlike the nuclei of the other species. The cuticle is relatively thin; the epidermis very thick, especially on the dorsal surface, and with a very coarsely fibrillated appearance. In sections of parts where the rhabdites are passing out, nearly all these fibrillæ prove to represent pore-canals, which are here very numerous, and, apparently, are quite devoid of the spaces found in the other species. The pigment is in larger and smaller rounded granules between and beneath the muscular layers.

6. TEMNOCEPHALA JHERINGII. Plate XIII. fig. 19, and Plate XV. fig. 2.

In general shape this species is similar to *T. fasciata* and *T. minor.* The body is dorsi-ventrally compressed, convex above, flat or slightly concave below, of an oval outline when looked at from the dorsal or the ventral side. In front are five subequal, dorsi-ventrally compressed tentacles. On the ventral surface behind is a sucker of circular outline, the margin of which projects backwards a little beyond the posterior border of the body, elevated on a short stalk. The mouth is a short, transversely directed slit situated on the ventral surface some distance behind the bases of the tentacles. The common genital aperture, in the form of a much smaller slit, also transverse, is situated some distance in front of the anterior border of the sucker. The integument is entirely devoid of pigment, and there are no eyes.

The pharynx is globular in shape, a little less than the breadth of the body. The intestine is squarish in outline; its walls are folded, but the deep incisions by which in the Australian species it is divided laterally are not present, the muscular septa being absent.

The testes are oval, situated close together, altogether behind the intestine, the more anterior, which is also more external, having its centre nearly opposite the common genital opening. The two vasa deferentia open into the dilated base of the cirrus, which forms a vesicula seminalis. The cirrus is nearly transverse in position, the free extremity reaching to the middle line. It is funnel-shaped, the wide end being continuous with the wall of the vesicula seminalis. At the free end is a slight enlargement, probably containing spines.

The vitelline glands have no tendency to an arrangement in transverse zones, such as is discernible in some of the other species. They form an irregular network

ramifying over the dorsal surface of the intestine, pass round its lateral borders and extend inwards for some distance on the ventral surface.

The receptaculum seminis is of oval outline, with thinner walls than in the Australian species. It is situated a little to the right of the middle line, immediately behind the intestine. The ovary, closely adherent to the receptaculum seminis, is of oval shape, and very closely resembles the corresponding organ in the Australian species.

T. Jheringii was found by Dr. v. Jhering in Brazil in the branchial cavity of a species of *Ampullaria*. It differs from *T. Semperi*, Weber—(1) in the absence of eyes; (2) in the form of the cirrus, which is very much wider at its proximal end, curved instead of straight, and with a terminal introvert of a different form; (3) in the first pair of testes being placed much further back; and (4) in the shape of the ovary.

7. TEMNOCEPHALA NOVÆ-ZEALANDIÆ. Plate X. figs. 4, 7 and 11; Plate XI. fig. 1; Plate XIII. figs. 17 and 18; Plate XIV. figs. 2 and 3.

Temnocephala Novæ-zealandiæ, Haswell, "On *Temnocephala*," etc. p. 284, pl. XXII. figs. 10 and 19.

The most characteristic external feature of this species is the possession of six tentacles, in which, however, it resembles *T. comes*. In size *T. Novæ-zealandiæ* is sometimes little less than *T. fasciata*, some specimens attaining a length of half an inch in the contracted condition, but is usually much smaller, in accordance with the smaller size of its crustacean host. In the larger specimens the dorsal surface is brownish or slate-colour owing to the presence of irregularly arranged granules of pigment beneath the basement-membrane and muscular layers; but small specimens are nearly or quite devoid of pigment except in the eyes, which are very small. In the pigmented specimens the course of the dorsal nerves, with the network to which they give rise is readily traceable owing to the pigment being absent or little developed along the course of the branches. In the unpigmented species a reddish tinge is sometimes given to the middle of the body by the colour of the alimentary epithelium. External vibratile cilia are not present, but the tactile cones are very numerous and prominent, particularly on the tentacles. The intestine has usually only three or four septa, but sometimes there are five or even six. The most anterior of the unicellular integumentary glands are aggregated together into definite rounded groups. The anterior testis is narrow, situated opposite the posterior half of the intestine, not reaching much behind the posterior border of the latter; the posterior testis is oval, nearly or quite completely behind the intestine; neither of them shows

any trace of lobulation. The ejaculatory sac is short and rounded. The cirrus, when at rest, is almost parallel with the long axis of the body, with the base forwards and the apex backwards; when extended it assumes a more oblique position. It is strongly curved, wide proximally, narrowing gradually distally, with a very definite introvert armed with numerous pointed spines of considerable length; it presents a considerable amount of variation in the length and arrangement of the spines. (Plate XIII. figs. 17 and 18.)

The vitelline glands are quite irregularly arranged in broad lobes. The receptaculum vitelli is not median, being situated to the right of the middle line. The feature of the internal structure which is most characteristic of the species is the large muscular vagina already described (p. 129) with its series of chitinous teeth. (Plate XIV. fig. 3.)

The eggs, which are small and pear-shaped, are attached by a short stalk situated at one end, usually to the anterior part of the carapace or to the great chelæ of the host; they are not connected together in any way like the eggs of some of the Australian species. The egg opens by the formation of a transverse fissure, resulting in the separating off of the distal end of the shell as a sort of operculum. When I had the opportunity of examining them (in the month of February) all the eggs either contained fully formed embryos or were empty, the young having escaped. The young specimens differ from the adult in the absence of the intestinal septa and the reproductive organs as well as of the pigment; they have no cilia. The terminal part of the cirrus with its spines is formed before the appearance of the toothed vagina.

This species lives on *Paranephrops neo-zealanicus* and *P. planifrons*, chiefly on the surface of the great chelæ among the hairs, and appears to be widely distributed in the rivers and lakes of New Zealand, both in the North and South Islands.

8. TEMNOCEPHALA ENGÆI. Plate XIII. fig. 20.

The largest specimen of this species which I have obtained is scarcely three millimetres in length in the contracted state. The general shape is similar to that of *T. minor;* there are five subequal slender tentacles, which are much shorter relatively than in that species; the sucker is relatively large, its diameter being nearly equal to a third of the length of the body. Pigment is completely absent, except in the pigment-cups of the very small eyes. Vibratile cilia are completely absent. The intestine appears to present about seven constrictions similar to those seen in most of the other species. The excretory sacs have their external openings further apart than is usual, quite close to the lateral borders of the body. The testes are oval, the long axis of the anterior testes being parallel with the long axis of the body, while that of

the posterior pair is nearly transverse. The anterior pair, which are the smaller, are situated behind the middle of the intestine; the posterior pair are altogether behind the intestine. The cirrus is narrower in proportion to its length than in most of the other species, strongly curved, with a distinct, very narrow, curved terminal segment apparently devoid of spinules.

The few specimens of this species which I have seen were obtained, some on the outer surface, others in the branchial chambers of *Engæus fossor*, the land crayfish of Gippsland.

9. TEMNOCEPHALA CHILENSIS.

Temnocephala chilensis, Blanchard, l.c.

The description of this species given by Philippi is not sufficient to enable one to distinguish it, as it would apply equally well to at least four kinds which a careful examination shows to differ in certain very essential particulars.

It was found, as already mentioned, on the surface of a species of *Æglea* in Chili. The specimens which Monticelli mentions as being in the Zoological Museum in Berlin, with the locality Brazil, and the eggs of which he describes, may belong to this species or to *T. Jheringii.*

10. TEMNOCEPHALA SEMPERI.

T. Chilensis, Semper (?), l.c. p. 307.

T. Semperi, Weber, l.c. p. 26.

This species has five subequal, slender tentacles, has the anterior testis situated nearly exactly opposite the middle of the intestine, and the posterior one nearly completely behind the latter; there is a short rounded ejaculatory sac; the cirrus is straight or nearly so, and its terminal part, slightly dilated, is armed with numerous extremely minute spinules.

It seems to me extremely unlikely that the species described by Semper and found by him on various fresh-water crabs in the Philippines is the same as that found by Weber in Sumatra, Java and Celebes; but though there are differences between Semper's figures and Weber's, particularly those of the cirrus, there is not enough evidence to decide the point.

11. TEMNOCEPHALA BREVICORNIS.

Temnocephala brevicornis, Monticelli, l.c. p. 1, foot-note; and "Di una nuova specie del genere *Temnocephala*, Blanch., ectoparassita dei Cheloniani."

This species is doubtless distinct from the others enumerated above, but is not sufficiently characterised by Monticelli; the points he mentions, length of tentacles, form of body and the like, being such as vary extremely according to the condition of the specimen. Monticelli regards *T. brevicornis* as approaching nearer to *T. minor*, mihi, than to any of the others, "ma se ne discosta perchè questa ha il corpo più slanciato ed i tentacoli esili (secondo Haswell)"; but these differences are merely due to the contracted state of Monticelli's specimens, and the internal organs will have to be examined before this species can be said to be known as distinct from the others. The specimens were found in 1856 by Reinhard in Brazil on the shell of the fresh-water Chelonians *Hydromedusa maximiliani* and *Hydropsis radiolata.**

12. TEMNOCEPHALA MADAGASCARIENSIS.

Temnocephala madagascariensis, Vayssière, "Etude sur le *Temnocephala* parasite de l' Astacoïdes madagascariensis," 'Annales de la Faculté des Sciences de Marseille.' Tome II., Fascicule v. (1892); 'Comptes Rendus,' Tome CXV. p. 64 (1892).

In this species there are no fewer than twelve cephalic tentacles. The sucker is very small. There is a large pharynx; the intestine does not appear to be distinctly constricted. There is a pair of eyes. The openings of the excretory sacs are situated on the lateral margins.

Vayssière's interpretation of the genital organs does not appear to me to be satisfactory. Should his statement be confirmed it would be necessary to regard the Madagascar species as generically distinct from *Temnocephala*. The eggs are supported on short stalks.

This species occurs on the surface of the Madagascar fresh-water crayfish (*Astacoides madagascariensis*).

Genus CRASPEDELLA (new).

A series of (five) papillose cephalic tentacles. On the dorsal surface a series of delicate transverse lamellæ divided into lobes tipped with papillæ. The pharynx rudimentary.

* While the above has been passing through the press I have received, through the kindness of Dr. Brandes, specimens of the species in question, and find that it is quite distinct from the others. The cirrus is relatively longer and narrower than in *T. Jheringii*, and is curved, slightly in the proximal three-fourths, strongly at the distal end, with a relatively small introvert provided with a few delicate spines. Eyes are not visible, but this may be due to the solution of the pigment.

CRASPEDELLA SPENCERI. Plate XIII. fig. 21, and Plate XV. fig. 3.

The general shape of the animal, which is very small, averaging less than 2 mm. in length, is similar to that of *Temnocephala minor*. In front there are five subequal tapering tentacles; these are covered with rows (two lateral, two dorsal) of conical papillæ ·01 mm. in length, about twelve in each row. Along the lateral and posterior borders are similar, but smaller, papillæ, arranged at pretty wide intervals. In the posterior half of the body, on the dorsal surface, are three thin transverse lamellæ, ·05 mm. in breadth, divided into about 15-20 rounded lobes, each tipped with a few papillæ similar to those on the lateral borders. Behind the last lamella are four conical processes projecting backwards and outwards, each with several minor elevations, all of these being tipped with a number of papillæ. The eyes are situated close together some distance behind the bases of the tentacles; the pigment of the eyes is in comparatively large rounded granules. There is no other pigment in the body.

The integument is similar to that of *Temnocephala:* it is devoid of vibratile cilia. The mouth is in the usual position, and leads into a very small chamber representing mouth-cavity and pharynx. The intestine appears squarish in outline when viewed from above or below, and somewhat unsymmetrical behind, owing to the position of the reproductive apparatus. It exhibits no trace of subdivision by means of septa.

The excretory system corresponds closely with that of *Temnocephala*. The same holds good of the integumentary glands and of the nervous system.

The anterior testis is oval, smaller than the posterior, situated at the side of the posterior part of the intestine. The posterior, irregularly triangular in outline, is situated altogether behind the intestine; the bulb of the cirrus lies between the two. The spermatozoa are similar to those of *Temnocephala*.

The cirrus (Pl. XIII. fig. 21) is strongly curved, with a comparatively long and narrow introvert provided with numerous short spines.

This species, the only member of the genus as yet discovered, lives in the branchial chambers of *Astacopsis bicarinatus*, climbing about actively among the gill-filaments. One specimen, however, was found outside the branchial cavities on the surface of the crayfish.

XVI.—AFFINITIES OF THE TEMNOCEPHALEÆ.

When first discovered *Temnocephala* was regarded by Gay as a Hirudinean, and the same view was adopted by Blanchard* and by Moquin-Tandon.† Philippi‡ regarded its nearest relative as being Malacobdella. In his "Animal Parasites and Messmates" (1876), P. J. van Beneden remarks on *Temnocephala* (written *Temnophila*):—"This messmate resembles a Trematode by its form and by its posterior sucker; but by its entire character, and especially by its sexual organs, it belongs to the *Turbellaria*" (p. 47 of the English edition). Semper§ was the first to set it down as an ectoparasitic Trematode, and in this he was followed by myself,‖ by Weber¶ and by Monticelli.** I proposed that it should be regarded as constituting a distinct family of the Monogenæa, more nearly related to the *Tristomidæ* than to the others, and in this opinion Weber and Monticelli concur. Braun's†† views have already been referred to: he denies the close relationship to the *Tristomidæ* and doubts if the *Temnocephaleæ* are completely established as Trematodes. In a separate paper‡‡ he summarizes our knowledge of the family and discusses the question whether *Temnocephala*, regarded as a monogenetic Trematode, is to be looked upon as primitive or as degenerate. Brandes§§ also expresses doubts as to the correctness of the view that *Temnocephala* is an aberrant Trematode, and directs attention to several important resemblances to the *Rhabdocœla*.

The integument of *Temnocephala* and *Craspedella* is quite exceptional if we are to regard them as ectoparasitic Trematodes. A complete distinct epithelial layer does not occur in other genera, though in some (*Nitschia* and *Epibdella*) as observed by Braun‖‖ such a layer is distinguishable on some parts of the surface, but without cuticle or basement-membrane. In the others the outermost layer of the body seems rather to correspond to the basement-membrane of the integument of *Temnocephala* than to a modified epidermis; it is homogeneous, does not readily become stained, and seems to be of a resistent character. On the other hand, in this particular *Temnocephala* approaches very near to the Rhabdocœle *Turbellaria;* the epidermal

* Gay's "Zoology of Chilé" II. p. 51.
† "Monographie des Hirudinés," p. 300.
‡ "Arch. f. Naturg." XXXVI. (1870), p. 35.
§ 'Zeitschrift f. wiss. Zoologie,' XXII. 1872, p. 307.
‖ 'Quart. Journ. Micro. Sci.' Vol. XXVIII. (1888).
¶ "Zoolog. Ergebnisse einer Reise," etc.
** "Saggio di una Morfologia dei Trematodi."
†† Bronn's "Klassen u. Ordnungen des Thier-Reichs, Vermes."
‡‡ "Ueber Temnocephala, zusammenfassender Bericht." 'Centralbl. f. Bact. u. Paras.' VII. (1890).
§§ "Zum feineren Bau der Trematoden." 'Zeitschr. f. wiss. Zool.' LIII. p. 558 (1892).
‖‖ *Tom. cit.* p. 422.

layer is of similar character in the two groups, and the presence of cilia in *T. minor* and *T. Dendyi* makes the resemblance very close. The basement-membrane is absent in the *Rhabdocœla*, but it would not appear to be present in all the species of *Temnocephala* (Weber).

A striking similiarity between the *Temnocephaleæ* and the *Rhabdocœla* is in the presence in both of the system of unicellular integumentary glands forming rhabdites (Stäbchen). The arrangement of their ducts in the former as they run forwards in the anterior region of the body into broad strands or "Stäbchenstrassen" precisely corresponds to what occurs and what I myself have seen in many Rhabdocœles; and nothing of the kind appears to have been observed among the Trematodes.

The structure of the pharynx is similar to what obtains in some of the Rhabdocœles, such as *Mesostomum;* but, on the other hand, it appears equally near to that of the corresponding organ in *Polystomum*, *Sphyranura* and certain other *Monogenetica*. The intestine and its epithelium closely resemble those of a Rhabdocœle, with the exception of the constrictions, which never occur in the latter.

The excretory system is quite peculiar, so far as our knowledge extends. It more nearly resembles that of the ectoparasitic Trematodes than that of the Rhabdocœles; the contractile, pulsating, terminal sacs being absent in the latter group, and almost universally present in the former. Of the five types of arrangement of the vessels described by von Graff (p. 105) that presented by *Prorhynchus stagnalis*, in which there are two lateral openings towards the middle of the body, from each of which a main vessel runs transversely for a little distance to become divided into anterior and posterior trunks, approaches most nearly that which occurs in *Temnocephala*.

In its nervous system *Temnocephala* exhibits one of the highest types of development among the Platyhelminthes, with its comparatively large brain, the rich development of nerves running forwards, the three pairs of posterior trunks, and the highly developed subcutaneous nerve-plexus. But in these respects it does not stand quite alone. In *Tristomum molæ*, as described by Lang,* all these features recur, and but for the less development of the anterior nerves and certain differences in the relations of the subcutaneous plexus (which in *Tristomum* is apparently equally contributed to by all three pairs of trunks), there is a very close correspondence between the two. Though a subcutaneous nerve-plexus is present in *Tricladidæ* and *Polycladidæ*, nothing of the kind has been noticed in the *Rhabdocœla*, and there would appear never to be more than one pair of nerve-trunks running backwards from the ganglion in that group. The eyes can be exactly matched among the *Rhabdocœla*, and, on the

* "Untersuchungen zur vergleichenden Anatomie u. Histologie des Nervensystems der Plathelminthen." 'Mittheil. a.d. Zool. Stat. zu Neapel,' II. Bd. p. 28.

other hand, are in all essential respects similar to those of *Tristomum molæ.* The tactile cones, so abundantly distributed on the tentacles and anterior part of the body in *Temnocephala* and *Craspedella,* and on the posterior fringes and processes of the latter genus, seem to have been found elsewhere in a similar shape only in *Sphyranura;* but the motionless hairs of many *Rhabdocœla* are evidently structures of the same fundamental character.

As regards the reproductive organs—it appears to me that *Temnocephala* finds closer alliances among the Rhabdocœles than among the ectoparasitic Trematodes; and of the former group various *Vorticidæ,* as described by von Graff and others, approach very near to it in the general arrangement of parts, as well as in the special character of the cirrus. A bursa copulatrix is absent in both *Temnocephala* and *Craspedella;* but the muscular "vagina" of *T. Novæ-zealandiæ,* though leading directly to the uterus and oviduct, may represent it, and the teeth in its interior, though more numerous, bear a striking resemblance to those of the bursa copulatrix of some of the Rhabdocœles, such as *Proxenetes flabellifer,* Jensen (von Graff, Taf. VIII. fig. 16). But spines or teeth occur round the opening of the oviduct in *Axine* and *Microcotyle.* The testes resemble the compact type of these glands occurring among the *Rhabdocœla;* but are also nearly approached by those of some ectoparasitic Trematodes. The ovary has in many Rhabdocœles the same form and relations as in *Temnocephala;* but in the form and arrangement of the ova within the ovary there is a much nearer resemblance to *Sphyranura* of the *Monogenæa.*

A remarkable point of resemblance between *Temnocephala* and the *Rhabdocœla* is in the system of accessory glands secreting rounded granules connected with the male reproductive apparatus in both groups. Von Graff's account of these structures as they occur in the Rhabdocœles applies equally well, word for word, to *Temnocephala*—the only difference of consequence being in the much greater length of the ducts in the latter case. The so-called prostate-glands of some *Monogenetica* are evidently the same structures less specially developed.

Stalked eggs similar to those of *Temnocephala* occur among the Rhabdocœles—the "stalk" in the latter, as in some of the species of *Temnocephala,* not always serving for the attachment of the egg. But similar eggs are met with also among the monogenetic Trematodes. Sufficient data are wanting for a comparison of the embryological history in the various groups under discussion. What is known does not seem to tell more in one direction than in another. The embryo of *Temnocephala* undergoes direct development and becomes fully formed while still within the egg—the reproductive apparatus alone remaining undeveloped. This direct development and absence of metamorphosis it shares equally with the monogenetic Trematodes and with the *Rhabdocœla.*

On the whole, a review of the evidence seems to me to point to the conclusion that the Trematode affinities of *Temnocephala* somewhat predominate over the Turbellarian. It presents an assemblage of characters which distinguish it very broadly from any individual member of the former class; but perhaps it has rather more important points of resemblance in the various features of its structure with now one now another ectoparasitic Trematode than with the Rhabdocœles. The large ventral sucker, the excretory sacs, and the nervous system may be set down as decidedly Trematode and not Rhabdocœle in character. The preponderance, however, if it occurs, is only slight, and I should see little reason for finding fault with anyone who should regard the *Temnocephaleæ* as aberrant Rhabdocœles specially modified in accordance with a peculiar mode of life.

XVII.—LIST OF THE PRINCIPAL WORKS AND PAPERS REFERRED TO.

BENEDEN, P. J. VAN, and HESSE, C. E. Recherches sur les Bdelloides et les Trematodes marins. Mem. Acad. Roy. des Sci. Brux. (1864).

BENEDEN, E. VAN. Encore un mot sur le nephridium et la cavité du corps des Trematodes et des Cestodes. Zool. Anz. V. (1882).

BENEDEN, P. J. VAN. Note sur l'appareil circulatoire des Trematodes. Ann des Sci. Nat., 3me Série, T. XVII. (1852).

BLANCHARD, E. Anularés in Gay's Historia fisica y politica de Chilé (1849).

BLOMFIELD. Review of recent researches in Spermatogenesis. Quart. Journ. Micro. Sci. XXIII. (1883).

BOHMIG, L. Untersuchungen über Rhabdocöle Turbellarien. Zeitschrift f. wiss. Zool. LI. (1891).

BRANDES, R. Zum feineren Bau der Trematoden. Zeitschr. f. wiss. Zool. LII. (1892).

BRAUN, M. Ueber die Lage des Excretionsporus bei den ectoparasitischen Trematoden. Zool. Anz. XI. (1889).

BRAUN, M. Ueber Temnocephala, zusammenfassender Bericht. Centralbl. f. Bacteriologie und Parasitenkunde, VII. (1890).

BUTSCHLI, O. Bemerkungen über den excretorischen Gefässapparat der Trematoden. Zool. Anz. II. (1879).

CHILTON, CHAS. Trans. New Zealand Institute, Vol. XXI. pp. 252-253.

FRAIPONT, J. Recherches sur l'appareil excréteur des Trematodes et des Cestodes. Archives de Biologie, II. (1881).

FRANCOTTE, P. Sur l'appareil excréteur des Turbellariés rhabdocœlès et dendrocœles. Arch. de Biol. II. (1881).

GAFFRON, E. Zum Nervensystem der Trematoden. Zoöl. Anz. VI. (1883). Also Biol. Centralblatt, IV.

GRAFF, L. v. Monographie der Turbellarien. I. Rhabdocœlida (1882).

HASWELL, W. A. On Temnocephala, an aberrant Monogenetic Trematode. Q. J. Micro. Sci. XXVIII. (1888).

HASWELL, W. A. On the excretory system of Temnocephala. Zool. Anz. (1892).

JENSEN, O. S. Recherches sur la Spermatogénèse. Arch. de Biol. IV. (1883).

KENNEL, v. Untersuchungen an neuen Turbellarien. Zool. Jahrbücher (1889).

KERBERT, C. Beitrag zur Kenntniss der Trematoden. Arch. f. Mikr. Anat. XIX. (1881).

LANG, A. Die Polycladen. Flora und Fauna des Golfes von Neapel.

LANG, A. Untersuchungen zur vergleichenden Anatomie u. Histologie des Nervensystems der Plathelminthen. Mittheil. aus der Zool. Stat. zu Neapel, I., II. and III.

LANKESTER, E. RAY. Notes on the embryology and classification of the animal kingdom. Quart. Jour. Micro. Sci. Vol. XVII. (1877).

LANKESTER, E. RAY. Primitive Cell-layers of the Embryo. Ann. Mag. Nat. Hist. (4), Vol. XI. (1873).

LANKESTER, E. RAY. On the body-cavity and nephridia of Platyhelmia. Zool. Anz. IV. (1881).

LANKESTER, E. RAY. The Cœlom and Nephridia of Flatworms. Zool. Anz. V. (1882).

MONTICELLI, F. S. Di una nuova specie del genere Temnocephala, Blanchard, ectoparasita dei cheloniani.

MONTICELLI, F. S. Breve nota sulle uova e sugli embrioni della Temnocephala chilensis, Bl. Atti della Società Italiana di scienze naturali, XXXII. (1889).

MONTICELLI, F. S. Della Spermatogenesi nei Trematodi. Bollettino della Società di Naturalisti in Napoli, Vol. V. (1891).

MOQUIN-TANDON. Monographie de la Famille des Hirudinés (1846).

PHILIPPI, R. A. Ueber Temnocephala chilensis. Archiv f. Naturgeschichte, XXXVI. (1870).

ST. GEORGE, V. LA VALETTE. Ueber d. Genese der Samenkörper. Arch. f. Mikr. Anat. XV. (1878).

ST. GEORGE, V. LA VALETTE. Spermatologische Beiträge. Arch. f. Mikr. Anat. XXV., XXVII. and XXVIII. (1885-1888).

SAINT REMY, G. Sur les organes genitaux des Tristomiens. Comptes Rendus CXVII. (1891).

SCHULTZE, MAX. Beiträge zur Naturgeschichte der Turbellarien.

SEMPER, C. Ueber die Gattung Temnocephala, Blanchard. Zeitschr. f. wiss. Zool. XXII. (1872).

VAYSSIERE, A. Etude sur le Temnocephala parasite de l'Astacoïdes madagascariensis. Annales de la Faculté des Sciences de Marseille, Tome II. fasc. v. (1892).

VILLOT, A. Sur l'appareil vasculaire des Trematodes. C.R. 1876.

VILLOT, A. Organisation et developpement de quelques espèces de Trematodes endoparasites marins. Ann. des Sc. Nat. Zool. 6^{me} Série, T. VIII. (1879).

VILLOT, A. L'appareil vasculaire des Trematodes, considéré sous le double point de vue de sa structure et de ses fonctions. Zool. Anz. V. (1882).

VOGT, C. Sur les organes reproducteurs de quelques Trematodes marines ectoparasites. Arch. de Zool. exp. et gén. Ueber die Fortpflanzungsorgane einiger ectoparasitischer mariner Trematoden. Zeitschr. f. wiss. Zool. XXX. (1878).

WEBER, MAX. Ueber Temnocephala, Blanchard. Zool. Ergebnisse einer Reise, etc.

WOOD-MASON, J. On the Geographical Distribution of the *Temnocephala chilensis* of Blanchard. Ann. Mag. Nat. Hist. (4) XV. (1875).

WRIGHT, R. R., and MACALLUM, A. B. Sphyranura Osleri, a contribution to American Helminthology. Journal of Morphology, Vol. I.

EXPLANATION OF THE PLATES.

PLATE X.

Fig. 1.—Integument and muscular layers of *T. fasciata*, from transverse section of a specimen fixed with Flemming's chrom-osm-acetic solution. *cu.*, cuticle; *t.c.*, tactile cones; *ep.*, epidermis; *b.m.*, basement-membrane; *c.m.*, circular layer of muscle; *l.m.*, longitudinal layer of muscle; *p.m.*, dorsi-ventral muscular bundles of the parenchyma. The black reticulating lines are the pigment; the lighter network the parenchyma. The spaces in the epidermis are here distinguishable, though small. The diagonal layer of muscle is not represented.

Fig. 2.—Integument of *T. fasciata*, from a transverse section of a corrosive sublimate specimen. Letters as in preceding figure. The epidermis here appears perforated by vertical channels, which are not greatly dilated. The cuticle is somewhat diagrammatically represented.

Fig. 3.—Surface view of the epidermis of *T. fasciata*, from a teased picrosulphuric acid specimen; numerous large clear spaces in the protoplasm.

Fig. 4.—Tangential section through the epidermis of a specimen of *T. Novæ-zealandiæ*, fixed with Flemming's solution. Throughout the protoplasm runs a system of branching and anastomosing fine canals, with here and there a rounded clear space.

Fig. 5.—From a tangential section of the integument of *T. fasciata*, passing through the deeper part of the cuticle. *t.c.*, base of a tactile cone.

Fig. 6.—Surface view of the epidermis of *T. fasciata*, from a specimen prepared by means of Flemming's solution, showing the minute elevations of the cuticle and a tactile cone—*t.c.*

Fig. 7.—Integument and body-wall of *T. Novæ-zealandiæ*, from a longitudinal section of a specimen prepared with Flemming's solution. The epidermis here exhibits numerous channels with frequent dilatations. A little space here separates the epidermis from the basement-membrane. The muscular layers are merely indicated. The larger and smaller granules are the pigment. *pa.*, parenchyma: other letters as in fig. 1.

Fig. 8.—Integument and body-wall of *T. Dendyi*, from a longitudinal section of a specimen fixed with osmic acid. Letters as in fig. 1. The cuticle and epidermis are not here sharply differentiated; the nuclei bulge downwards towards the basement-membrane. The basement-membrane exhibits a finely reticulate structure with occasional vertical lines apparently indicating the position of the pore-canals.

Fig. 9.—One of the nuclei of the parenchyma.

Fig. 10.—Group of problematical cells in parenchyma.

Fig. 11.—Excretory sac of *T. Novæ-zealandiæ*, from a living specimen. *o.*, external opening; *v.*, beginning of main vessel.

Fig. 12.—Capillary vessels ramifying in the wall of the excretory sac of *T. Dendyi*. *s.*, outline of sac; *l.v.*, main longitudinal vessel. The capillary channels extend through the entire substance of the protoplasm of the sac; only a few of them are represented.

Fig. 13.—Section of the excretory sac of *T. fasciata*, from a longitudinal vertical section through a specimen prepared by Flemming's method. *c.*, central cavity of the sac; *mu.*, investing layer of muscular fibres; *ca.*, narrow part of the central cavity of the sac. × 250.

Fig. 14.—Section of the excretory sac of *T. fasciata*, from a longitudinal section of a specimen prepared by Flemming's method. The section does not pass through the central cavity, but is selected because it shows the continuity of the protoplasm of the narrow end of the sac and beginning of the main canal with that of the wall of the main portion of the former. *ca.*, lumen of commencement of main canal; *nu.*, the two nuclei. The nuclei are not divided through the middle, but near the periphery, so that their relative size is not shown.

Fig. 15.—A small part of the section represented in fig. 13, showing the minute structure of the wall of the sac with some of the capillaries. × about 2000.

Fig. 16.—A longitudinal section through one of the larger excretory vessels of *T. fasciata*, showing the nucleus of one of the perforated cells. From a series of longitudinal sections × 500. The double border of the canal is due to an error of the lithographer.

Figs. 17 and 18.—Two successive longitudinal sections through the basal part of a tentacle of *T. Dendyi*, showing perforated cell with the twisted tentacular main vessel and portions of branches.

PLATE XI.

Fig. 1.—General view of the arrangement of the principal excretory vessels in *Temnocephala Novæ-zealandiæ*. *t.s.*, terminal sac; *ph.*, pharynx; *i.*, intestine; *t.t.t.t.*, testes; *s.*, sucker.

Fig. 2.—Excretory cell of *T. fasciata*, section of central part to show nucleus and capillary channels.

Fig. 3.—Excretory cell with branch vessel entering it and breaking up into capillaries.

Fig. 4.—Unipolar ganglion-cell, highly magnified.

Fig. 5.—Section through the brain of *T. Dendyi*, from a series of horizontal sections of the animal, showing the transverse curved band of fibrous material and some of the ganglion-cells. *ph.*, pharynx.

Fig. 6.—Eyes of *T. Dendyi*, from a series of horizontal sections. *p.c.*, pigment-cups; *r.b.*, refractive bodies, seen also projecting through the bases of the cups; *c.*, cells similar to nerve-cells, closely applied to the refractive bodies; *x.*, large non-nervous cells; *n.c.*, nerve-cells.

Fig. 7.—Eye and brain of *T. fasciata*, from a series of vertical longitudinal sections. *p.c.*, pigment-cup; *r.b.*, contained refractive body; *c.*, one of the cells similar to nerve-cells closely applied to the mouth of the cup; *r.c.*, retinal cells; *f.*, central fibrous mass of brain.

Fig. 8.—Approximately median section of the brain of *T. fasciata*, from a series of vertical longitudinal sections of the animal, to show the arrangement of the large channels, *ch.*, with their contents, and the fibrous mass, *f.* *ph.*, pharynx; *pr.*, bands of parenchyma muscle which act as the protractors of the pharynx; *i.*, position of the integument of the dorsal surface; *ph.*, pharynx; *ch'.*, detached group of channels and fibres.

Fig. 9.—Eye and neighbouring parts in *T. fasciata*, from a series of horizontal sections. *p.c.*, pigment-cup; *r.b.*, refractive body; *r.c.*, "retinal" cells; *x.x'.*, problematical cells, which are always symmetrically arranged in this region; the nuclei are not mesially divided; *x''.*, nucleus of a similar cell. The rest of the cells represented are ganglion-cells. The brown spots are dorsi-ventral bands of parenchyma muscle, many of them perforating the large cells. The irregular network of dark lines continuous with the pigment of the eye are the strands of pigment in the parenchyma.

PLATE XII.

Fig. 1.—General view of the dorsal nerve-plexus as seen in a young specimen of *Temnocephala fasciata*, with the origin of the nerves given off to the tentacles.

Fig. 2.—Eye of *T. minor* as seen in fresh specimen.

Fig. 3.—System of visceral nerves in the pharynx of *T. fasciata*, from a compressed specimen stained with methyl green. *m.*, median; *l.*, lateral longitudinal nerves; *r.*, radial branches. The dotted line, *ph.*, indicates the outline of the pharynx.

Fig. 4.—A portion of one of the pluricellular "prostatic" glands as seen in a section of a specimen prepared by Flemming's method. *d.*, duct.

Fig. 5.—Transverse section of the main duct of the "prostate" glands. × 500.

Fig. 6.—Branching and anastomosing ducts of the "prostate" glands. × 500

Fig. 7.—Cirrus of *T. Dendyi* protruded through the common genital aperture, from a series of vertical longitudinal sections. *g.o.*, points to the genital aperture.

Fig. 8.—Cirrus of *T. minor*. *c.*, genital cloaca.

Fig. 9.—Extremity of cirrus of young specimen of *T. minor*.

Fig. 10.—Longitudinal section of the cirrus of *T. quadricornis*, showing the three sets of spines.

Fig. 11.—The cirrus and adjacent parts of *T. Dendyi* from the dorsal aspect × 230 (fresh specimen). *b.*, cirrus bulb; *c.*, cirrus; *e.s.*, ejaculatory sac; *l.g.r.*, left granule reservoir; *r.g.r.*, right granule reservoir; *l.v.d.*, left vas deferens; *r.v.d.*, right vas deferens; *o.*, male opening into genital cloaca; *v.s.*, vesicula seminalis (here not greatly distended); *t.*, points to the median spine.

PLATE XIII.

Fig. 1.—Cells from testis of sexually immature specimen of *T. Dendyi*.

Fig. 2.—Spherical mass of cells formed by division of primitive cell of testis.

Fig. 3.—A stage in the further mitotic division of the testicular cells.

Fig. 4.—Final stage in the process of division—the spermatidia.

Figs. 5-11.—Successive stages in the development of the spermatozoa.

Fig. 12.—Heads of spermatozoa of *Temnocephala fasciata*.

Fig. 13.—Cirrus of *T. fasciata*. *i.*, introvert; *c.*, genital cloaca.

Fig. 14.—Cirrus of variety of *T. fasciata*.

Fig. 15.—Cirrus of *T. comes*. *e.s.*, ejaculatory sac (in some specimens a good deal longer than here represented); *i.*, introvert.

Fig. 16.—Distal extremity of the same, more highly magnified.

Fig. 17.—Cirrus of *T. Novæ-zealandiæ*.

Fig. 18.—Extremity of cirrus of *T. Novæ-zealandiæ*.

Fig. 19.—Cirrus of *T. Jheringii*.

Fig. 20.—Cirrus of *T. Engæi*.

Fig. 21.—Cirrus and neighbouring parts of *Craspedella Spenceri.* *i.*, introvert of cirrus; *e.s.*, ejaculatory sac; *g.r.*, granule reservoir; *g.d.*, right granule duct; *v.s.*, vesicula seminalis.

PLATE XIV.

Fig. 1.—Longitudinal, nearly horizontal section of *T. fasciata* (Flemming's strong solution and alum-cochineal). *e.*, epidermis and cuticle; *m.*, longitudinal layer of muscle; between *e.*, and *m.*, the dark band represents the thickly pigmented layer; *pr. pr.*, "prostate" glands; *t.s.*, posterior narrow part of terminal sac of excretory system; *t.g.*, group of tentacular unicellular glands; the dark bands running forwards and inwards from this are the strands of ducts; *t.*, anterior, *t'.*, posterior testis; in these the dark outline represents the muscular investment, and the lines running from this into the substance of the testes the incomplete trabeculæ; *n.*, part of the ventral nerve-cord; *v.s.*, vesicula seminalis; *c.*, cirrus; *u.*, uterus; *r.v.*, receptaculum vitelli; *b.*, points to the ventral part of the brain, with the origins of the posterior nerve-cords; in front of this are obliquely divided nerves and some excretory cells; the black dots and lines are the dorsi-ventral bundles of muscular fibres of the parenchyma, here darkly stained by the osmic acid; *ph.*, points to the lumen of the pharynx; the various layers of muscle are not all clearly distinguishable here; the radial fibres are distinct; the homogeneous-looking masses are sections of the anterior and posterior "sphincters"; *i.*, is placed in the lumen of the intestine; the investing muscular layer is represented by the dark outer line, and the *septa* by the lines running inwards from this.

Fig. 2.—*Temnocephala Novæ-zealandiæ*, from a living specimen. *t.s.*, terminal sacs of the excretory system; *m.*, mouth; *ph.*, pharynx; *i.*, intestine; *t.t.t.t.*, testes; *r.v.*, receptaculum vitelli; *ov.*, ovary; *v.*, vagina; *c.*, cirrus; *v.s.*, vesicula seminalis.

Fig. 3.—The muscular vagina of *T. Novæ-zealandiæ*, with its teeth, as seen in a longitudinal vertical section. *o.d.*, oviduct; *ut.*, uterus; *v.*, lumen of vagina with the chitinous teeth; *cl.*, genital cloaca; *m.m.*, masses of muscular fibres.

Fig. 4.—Section of the integument and muscular layers of *T. quadricornis.* *cu.*, cuticle; *ep.*, epidermis; *b.m.*, basement-membrane; *c.m.*, layer of circularly disposed muscular fibres; *p.*, layer of pigmented parenchyma between the muscular layers; *p'.*, outer part of central parenchyma with large rounded granules of pigment; *l.m.*, longitudinally arranged layer of muscle.

PLATE XV.

Fig. 1.—Semi-diagrammatic view of the organisation of *Temnocephala minor;* the animal is represented as somewhat contracted; the vitelline glands, the shell-glands and the nervous system are not represented. *ph.*, pharynx; in front of it the eyes, with a portion of the pigment-network; *i.*, intestine with its septa; *t.s.*, terminal sacs of excretory system; *r.g.*, rhabdite-forming tentacular glands; *r.d.*, ducts of the same where they become dilated; *t.*, testes; *v.s.*, vesicula seminalis; *e.s.*, ejaculatory sac; *c.*, cirrus; *g.c.*, genital cloaca; *r.v.*, receptaculum vitelli; *o.*, ovary; *ut.*, uterus; *pr.*, some of the prostate or granule-forming glands (only diagrammatically represented).

Fig. 2.—Ventral view of *T. Jheringii*, from a preserved specimen. *m.*, mouth; *g.a.*, genital aperture; *v.*, vitelline glands; the other letters as in fig. 1.

Fig. 3.—*Craspedella Spenceri*, dorsal view; letters as in preceding figures.

ON AN APPARENTLY NEW TYPE OF THE PLATYHELMINTHES (TREMATODA ?).

Baldwin Spencer, of Melbourne, for his kindness in procuring the specimens for me and in facilitating in every way my work at this subject—most of which was done in his laboratory in Melbourne.

II.—General External Features.

Actinodactylus is a very small worm, averaging about 1 mm. in length by ·3 mm. in greatest breadth. It is dorsi-ventrally compressed, convex above, flat below, devoid of segmentation, external or internal. In outline it may be described as pear-shaped, the narrower end being anterior. At the anterior end there is, in the living and extended condition, a small rounded cephalic lobe ; at the sides of this are a pair

Fig. 21.—Cirrus and neighbouring parts of *Craspedella Spenceri.* *i.*, introvert of cirrus; *e.s.*, ejaculatory sac; *g.r.*, granule reservoir; *g.d.*, right granule duct; *v.s.*, vesicula seminalis.

PLATE XIV.

Fig. 1.—Longitudinal, nearly horizontal section of *T. fasciata* (Flemming's strong solution and alum-cochineal). *e.*, epidermis and cuticle; *m.*, longitudinal layer of muscle; between *e.*, and *m.*, the dark band represents the thickly pigmented layer; *pr. pr.*, "prostate" glands; *t.s.*, posterior

CORRIGENDUM.

Since this paper passed through the press my attention has been directed by Prof. R. Blanchard, of Paris, to the fact that a genus *Actinodactylus* was established in 1890 by Duchassaing for a Tunicate. I, therefore, propose to alter the termination, making it *Actinodactylella.* I have omitted to give a specific name in the paper, and now propose to call this remarkable worm *Actinodactylella Blanchardi.*—W. A. H.

PLATE XV.

Fig. 1.—Semi-diagrammatic view of the organisation of *Temnocephala minor;* the animal is represented as somewhat contracted; the vitelline glands, the shell-glands and the nervous system are not represented. *ph.*, pharynx; in front of it the eyes, with a portion of the pigment-network; *i.*, intestine with its septa; *t.s.*, terminal sacs of excretory system; *r.g.*, rhabdite-forming tentacular glands; *r.d.*, ducts of the same where they become dilated; *t.*, testes; *v.s.*, vesicula seminalis; *e.s.*, ejaculatory sac; *c.*, cirrus; *g.c.*, genital cloaca; *r.v.*, receptaculum vitelli; *o.*, ovary; *ut.*, uterus; *pr.*, some of the prostate or granule-forming glands (only diagrammatically represented).

Fig. 2.—Ventral view of *T. Jheringii,* from a preserved specimen. *m.*, mouth; *g.a.*, genital aperture; *v.*, vitelline glands; the other letters as in fig. 1.

Fig. 3.—*Craspedella Spenceri,* dorsal view; letters as in preceding figures.

ON AN APPARENTLY NEW TYPE OF THE PLATYHELMINTHES (TREMATODA ?).

By William A. Haswell, M.A., D. Sc., Challis Professor of Biology, University of Sydney.

(Plate xvi.)

I.—Introductory.

When examining a spirit specimen of *Engæus fossor*, the remarkable burrowing crayfish of Gippsland, Victoria, for specimens of *Temnocephala*, I found a number of examples of the animal about to be described. Owing to the character of the integument, the presence of tentacles and other features, I was at first of opinion that the new form was related to the *Temnocephaleæ* and intended to include an account of it in my monograph of that family. But having taken advantage of the opportunity presented by a visit to the neighbouring colony to examine specimens in the living condition, as well as sections of specimens hardened by special methods, I have come to the conclusion that the differences between the new form, which I propose to name *Actinodactylus*, and *Temnocephala* are far too great to permit of their inclusion in a single family.

I have pleasure in here expressing my indebtedness to my friend Prof. W. Baldwin Spencer, of Melbourne, for his kindness in procuring the specimens for me and in facilitating in every way my work at this subject—most of which was done in his laboratory in Melbourne.

II.—General External Features.

Actinodactylus is a very small worm, averaging about 1mm. in length by ·3mm. in greatest breadth. It is dorsi-ventrally compressed, convex above, flat below, devoid of segmentation, external or internal. In outline it may be described as pear-shaped, the narrower end being anterior. At the anterior end there is, in the living and extended condition, a small rounded cephalic lobe ; at the sides of this are a pair

of short, sub-cylindrical tentacles, and behind these are five more pairs of tentacles of relatively considerable length when fully extended, radiating outwards from the lateral margins of the body—the more anterior directed forwards as well as outwards, and the more posterior backwards and outwards. Behind, on the ventral surface, is a large circular posterior sucker situated close to the posterior end of the body, and in front, below and a little behind the head-lobe, is a smaller, pit-like, anterior sucker not raised above the general surface. The animal moves, exactly after the manner of a leech, by the extension and contraction of the body and alternate fixation of the suckers. These movements are as rapid as those of *Temnocephala* or *Craspedella*. The tentacles are never employed in locomotion, and in fact I have never seen them being used in any way, though they may be observed to become extended and contracted and to undergo slight quivering movements: the probability is that they are only brought into play for the seizure of living prey.

The aperture of the mouth is a slit situated some little distance behind the anterior sucker. There is a single genital aperture situated just in front of the anterior margin of the posterior sucker. There are no eyes.

The body is completely devoid of pigment, but the internal organs are, nevertheless, very difficult to study, owing to the numerous bright granules which are scattered through the parenchyma. The whole animal is very much softer and more delicate than is the case with *Temnocephala*—a very slight pressure serving to crush it.

No observations were made on the nature of the food; the intestine was empty in all the specimens examined, or at least contained no recognisable particles, except in three, in each of which one of the Nematodes that infest the branchiæ of the Engæus in large numbers had apparently been partially swallowed. I think it is extremely likely that *Actinodactylus* resembles *Temnocephala* in its mode of feeding; its remarkable activity, the fringe of sensitive tentacles, and other features in its organisation yet to be described, seem adapted to such a mode of life.

III.—INTEGUMENT AND MUSCULAR LAYERS.

Actinodactylus resembles *Temnocephala* in having an integument (fig. 3) consisting of cuticle, nucleated epidermal layer, and, perhaps, basement-membrane. Scattered over the surface along the lateral margins and on the tentacles are numerous elevations of a conical form, each with a group ef non-motile cilia similar to the cilia of the tactile cones of the *Temnocephaleæ*, but relatively longer. Similar cilia not placed on cones occur in small numbers about the ends of the tentacles. There are

no vibratile cilia in any part. The cuticle and epidermis are, taken together, only about ·003 mm. in thickness—the epidermis taking up more than half of this. The epidermis resembles that of *Temnocephala* in being nucleated, but not divided into cells—the nuclei being about ·02 mm. apart on an average. Pore-canals and clear spaces are recognisable in the epidermis as in that of *Temnocephala*. Of the presence of a basement-membrane I am uncertain; appearances in some sections would seem to point to its presence; but the smallness of the object renders the determination of this and other points in its minute structure doubly difficult. An external circular and internal longitudinal layer of muscular fibres underlie the integument, but I have not seen any trace of the intermediate diagonal layer present in *Temnocephala*. Numerous dorsi-ventral bundles of muscular fibres traverse the parenchyma.

The ducts of the rhabdite-forming glands for the most part pass into the tentacles; but some of them reach the exterior in the interspaces between these appendages.

IV.—Alimentary Canal.

The most remarkable feature of *Actinodactylus*, revealed by an examination of living specimens, is the presence of a proboscis (Pl. xvi. fig. 2) capable of being retracted within the cavity of the mouth. In only one specimen did I find this organ fully protruded; and, but for the observation of this specimen, I should have entirely overlooked it, as its character is not readily recognisable in my series of sections. Having once seen it, however, I afterwards succeeded in finding two or three specimens in which it could be seen in the act of being imperfectly extruded and then withdrawn.

When fully extended this remarkable organ passed out beyond the margin of the body—equalling in length probably about one-third of the total length of the animal. It is of about the same thickness as the tentacles, but, unlike the latter, extremely sensitive and contractile. At its extremity is a pin-shaped stylet. When it was retracted I could find no trace of it either in living specimens examined under a slight pressure or in stained specimens; it appeared to vanish completely within the muscular pharynx, and more successfully prepared specimens will be required before its relation to the latter can be determined.

The pharynx (fig. 4) is comparable to that of *Temnocephala*. Enclosing it externally, as in a sort of sheath, is a thin layer of transversely arranged muscular fibres. Within this the radial fibres, which are stronger than in the *Temnocephaleæ*, take their origin, running inwards to the internal lining membrane. Running among the outer ends of the radial fibres is an outer stratum of longitudinal fibres, and among the inner ends an inner stratum—both being of considerable thickness. Internal to

the internal longitudinal layer is an irregular incomplete layer of circularly arranged fibres. The internal lining membrane is non-nucleated, appears homogeneous and may be cuticular.

The intestine is small, unbranched, with a small undivided cavity; the wall can, even less than in *Temnocephala*, be described as a complete epithelium—no division into cells being visible.

V.—EXCRETORY AND NERVOUS SYSTEMS; REPRODUCTIVE ORGANS.

Neither in the living condition nor in sections have I been able to see excretory vessels. The contractile terminal sacs, so readily recognisable in *Temnocephala* and *Craspedella*, are here completely absent; and I can find no trace of external excretory apertures. That an excretory system is present is evidenced, however, by the presence of vibrating flames. One of these was observed in the middle of each tentacle, not far from its extremity, and one or two in various parts of the body.

The brain occupies the same position, in front of the pharynx, as in *Temnocephala*, and as in other forms consists of a fibrous band with symmetrically arranged lateral groups of ganglion-cells. The arrangement of the nerve-cords is not traceable in my preparations. If we except the taetile cones, there are no organs of special sense.

The single genital aperture leads into a genital cloaca (fig. 5, *g.*), into the interior of which the cirrus projects on the left-hand side. The cirrus (*c.*) resembles that of some of the species of *Temnocephala*,—of tubular form, wider at its proximal than at its distal end, with an introvert armed with numerous uniform, relatively long and sharp spines.

The two pairs of testes (fig. 1, *t.*) are both of rounded form; the posterior pair are situated far back near the posterior extremity of the body; the anterior pair just behind the intestine. Each testis has its own vas deferens; on either side the two vasa deferentia soon combine to form a common vas deferens—right or left as the case may be. The right and left vasa deferentia open close together into the elongated vesicula seminalis, which is similar to that of *Temnocephala*.

The receptaculum vitelli (figs. 1 and 5, *r.v.*) resembles the corresponding organ in *Temnocephala*, and occupies a similar sub-median position just behind the intestine. It has a thick, protoplasmic wall with a small number of large nuclei similar to those of the ova. The ovary (*ov.*) is of oval shape, closely applied to the right-hand side of the receptacle. It is precisely like that of *Temnocephala*, with the narrow pyramidal ova extending transversely across it. In the short division of the oviduct leading to the ovary are three remarkable, curved, pointed (chitinous ?) spines or

hooks (*s.*). The oviduct dilates below to form the uterus (ootype), which opens by a short passage into the genital cloaca. Opening into the uterus is a very muscular spherical bursa copulatrix (*b.c.*), the interior of which is beset with closely placed short spines or teeth. The vitelline glands (*v.v.*) consist of a number of irregularly arranged lobes which are situated in close apposition to the intestine.

VI.—AFFINITIES OF ACTINODACTYLUS.

In certain respects *Actinodactylus* exhibits, it seems to me, more decided Trematode affinities than the *Temnocephaleæ*. But if we are to look on the former as a Trematode, we have to recognise that it is widely separated from any of the hitherto-described families of that class. It is Trematode-like in general form, in the presence of anterior and posterior suckers, in the absence of vibratile cilia, and in the general character of the alimentary canal and reproductive apparatus. It differs from all the described forms, not only in the possession of the marginal tentacles, and of a nucleated epidermis (the latter of which features it shares with the *Temnocephaleæ*), but in the presence of the remarkable buccal proboscis—an organ that is not precisely paralleled in any other group of worms. The relationship with *Temnocephala*, in spite of a certain superficial resemblance, is probably not by any means close: the chief point of resemblance, in addition to the presence in both of tentacles, is in the character of the integument. In the presence of an anterior sucker, of a buccal proboscis and of a bursa copulatrix, and in the absence of contractile excretory sacs, *Actinodactylus* differs from the *Temnocephaleæ*.

If, then, we rank *Actinodactylus* as a monogenetic Trematode, we have to regard it as the type of (at least) a new family. The following may be given as the general characteristics of the family *Actinodactyleæ* so far as our present knowledge extends:—

Flatworms with elongate, pear-shaped, somewhat compressed body, provided along the lateral margins with a series of tentacles. A small anterior and a large posterior sucker present. Surface covered with a thin, homogeneous cuticle, beneath which is a nucleated protoplasmic layer or epidermis containing pore-canals and spaces. Mouth some distance from the anterior end. A highly extensile protrusible buccal proboscis armed at its extremity with a minute stylet, usually retracted within the muscular pharynx. Intestine a simple sac without diverticula; its walls without definite epithelium. No external excretory openings. A single median genital aperture behind the intestine. A single compact oval ovary; a receptaculum vitelli, oviduct and uterus. Vitelline glands consisting of a number of lobes closely applied to the intestine. A bursa copulatrix with muscular walls and chitinous teeth opening into the uterus. Two pairs of compact testes, each with a separate duct. A chitinous cirrus armed terminally with spines.

EXPLANATION OF PLATE.

PLATE XVI.

Fig. 1.—Semi-diagrammatic general view of the external form and internal organisation of *Actinodactylus*, viewed from the dorsal aspect, the body moderately extended. *br.*, points to the position of the brain; *ph.*, pharynx; *v.v.*, some of the irregular lobes of the vitelline gland; *i.*, intestine; *ov.*, ovary; *ut.*, uterus; *b.c.*, bursa copulatrix; *t.t.t.t.*, testes; *v.s.*, vesicula seminalis; *c.*, cirrus; *r.v.*, receptaculum vitelli; *s.*, posterior sucker.

Fig. 2.—Ventral view of the head end; the animal is more contracted than that represented in fig. 1. *s.* anterior sucker; *p.*, proboscis. The representation of the proboscis cannot lay claim to perfect accuracy, as a view of it favourable to making a drawing was not obtained.

Fig. 3.—Section of the integument of *Actinodactylus*. *cu.*, cuticle; *ep.*, epidermis; *b.m.*, basement-membrane (?); *c.m.*, circular layer of muscle.

Fig. 4.—From horizontal section of pharynx, showing section of the lateral wall. *e.c.*, external circular layer; *e.l.*, external longitudinal layer; *r.*, radial fibres; *i.l.*, internal longitudinal; *i.c.*, internal circular; *e.*, internal lining membrane.

Fig. 5.—Reproductive apparatus of *Actinodactylus* as seen in living specimen. *r.v.*, receptaculum vitelli; *ov.*, ovary; *o.d.*, oviduct; *s.*, oviducal spines; *ut.*, uterus; *b.c.*, bursa copulatrix; *g.*, position of genital cloaca; *v.d.*, left, *v.d'.*, right, vas deferens; *v.s.*, vesicula seminalis; *c.*, cirrus.

OBSERVATIONS ON THE MYOLOGY OF *PALINURUS EDWARDSII*, HUTTON.

By Professor T. Jeffery Parker, D.Sc., F.R.S., and Josephine Gordon Rich.

(From the Biological Laboratory of the University of Otago.)

(Plates XVII.-XXI.)

CONTENTS.

The sea-crayfish of New Zealand *(Palinurus Edwardsii)* and its Australian ally *(P. Hügelii)* form such convenient students' types that it is extremely desirable to have a readily accessible account of their anatomy. The ordinary text-books deal almost exclusively with the *Astacidæ (Astacus* and *Homarus)*, and we have been able to find only detached observations on *Palinurus*, and these mostly on the European form *P. vulgaris*, which differs in so many respects from the species under consideration* as to render a detailed description of the latter necessary.

* See Parker, Trans. N.Z. Inst. Vol. XIX. (1886), p. 150 ; and Spence Bate, Challenger Reports, Vol. XXIV.

The exoskeleton of *P. edwardsii* has been described somewhat fully by one of us,* and the description will be referred to whenever it may be necessary to describe the relations of the muscles and aponeuroses to the hard parts.

An interesting result of our observations is to show the incorrectness of the commonly received opinions that the whole of the great internal mass of abdominal muscles consists of flexors. Milne-Edwards' account of the abdominal muscles of *Homarus*† is still the standard authority on the subject, and is followed in all the text-books.‡ As, however, we hope to show, he overlooked the fact that certain of what he called "muscles fléchisseurs" really act as extensors. That this is not a peculiarity of the Loricata, we have proved by an examination of *Paranephrops* in which the general structure is so similar to that of the other *Astacidæ* as to warrant the assumption that there is no fundamental difference in the muscular system.

Another point of considerable morphological interest is the discovery of certain vestigial muscles connected with the fused and immovable coxopodites of the antennæ.

I. THE AXIAL MUSCLES.

1. *Muscles of the abdomen.*

It is convenient to describe the whole mass of abdominal muscles as consisting of a dorsal, a ventral and a lateral set: the dorsal muscles are purely extensors, the ventral act partly as flexors, partly as extensors, the lateral as rotators.

The *dorsal muscles* (figs. 1 and 10) consist of a superficial and a deep set of extensors.

The *superficial extensors* consist of delicate sheets of muscle lying immediately beneath the dorsal integument of each segment, and passing in a longitudinal direction from the anterior border of each tergum to the anterior border of its successor. The muscle of each segment consists of two portions on each side of the middle line; the fibres of the mesial portion are straight, those of the lateral portion slightly oblique.

The superficial extensors of the first abdominal segment arise from the tergal region of the carapace immediately posterior to the heart. In the sixth segment these muscles are absent.

* Parker, "On the Skeletons of the N.Z. Crayfishes." Wellington (Col. Mus. and Geol. Surv. Dept.), 1889.

† H. Milne-Edwards, "Hist. Nat. des Crustacés," 1834, p. 151, Pl. XIII.

‡ See, *inter alia*, Huxley, "The Crayfish," p. 99; Howes, "Atlas of Pract. Elem. Biology," Pl. VIII. fig. 24; Huxley and Martin, "Pract. Biology," Revised Ed. p. 205; Lang, "Text-book of Comp. Anat." Vol. I. p. 331; Lemoine, Ann. des Sci. Nat. Zool. 5^{me} série, T. IX. p. 228.

The *deep extensors* are much larger than the superficial, and lie immediately beneath them. They consist of paired longitudinal bands extending continuously from end to end of the abdomen and connected by delicate aponeurotic bands with the anterior border of each tergum.* At the places of origin of the aponeuroses the muscle is constricted so as to have a distinctly segmented character. Like the superficial, the deep extensor of each side is divisible into a mesial and a lateral portion: in the mesial portion the fibres take a spiral course, in the lateral portion they are straight.

The deep extensors are continued into the thorax to a far greater extent than the superficial. The muscle of each side arises by five distinct slips from the portions of the epimeral plate corresponding to the five legs. The slips, uniting, form a strong band which passes backwards, inwards, and slightly upwards to the tergum of the first abdominal segment, to which it is connected by a sheet of ligament. The portion of the deep extensor contained in the sixth segment, and acting as a levator of the telson, presents only one obliquely placed bundle of fibres on each side of the middle line.

The *ventral muscles* (figs. 2, 8, 9 and 10) of the abdomen also consist of a superficial and a deep layer, the former of which are pure flexors, while the latter act partly as flexors, partly as extensors.

The *superficial flexors* consist of extremely delicate sheets of muscle in close contact with the sternal integument, and passing from the posterior edge of a given sternum to the posterior edge of the sternum next following. Each inter-sternal space contains two such muscular bands set somewhat obliquely a short distance from the middle line so as to enclose a V-shaped space with its apex backwards.

The superficial flexor of the first abdominal segment arises from a process of the sternal region of the thorax between the origins of the fourth and fifth pairs of legs.

The *deep ventral muscles* are of immense size and extraordinary complexity. They differ in important respects from those of *Homarus*, as described by Milne-Edwards; unfortunately we have no spirit specimens of the latter genus for comparison.

On viewing the whole of the ventral muscles from above as they are exposed by the removal of the terga and of the dorsal muscles, there is seen in each of the first five segments of the abdomen, as well as in the posterior region of the thorax, a paired transverse band of muscle, the fibres of which turn downwards both mesially and laterally so as to form a loop or arch open below. These bands may be

* The extensors are incorrectly figured by Huxley ("The Crayfish"), Howes ("Atlas"), and Lang ("Text-book of Comp. Anat.") as being inserted into the inner surface of the tergum near the middle.

distinguished as the *enveloping muscles,* since they enclose certain other bands presently to be described. Each may be described as being continued into a *mesial* or *inner limb,* which is in contact with its fellow of the opposite side, and a *lateral* or *outer limb,* which immediately underlies the skin of the pleural region. The inner is considerably wider than the outer limb, so that in a sagittal section of the abdomen each enveloping muscle is seen to extend to a considerable distance into the next following segment.

Immediately anterior to the enveloping muscle of the first five abdominal segments are two bundles of fibres, the cut ends of which are exposed by the removal of the terga, into which they are therefore inserted. The insertion of the dorsal of these bundles is above the inter-segmental hinge, and the muscle must therefore act as an extensor and not, like the greater part of the ventral muscles, as a flexor: it may be called the *oblique extensor.* As will be seen hereafter, it arises from what Milne-Edwards calls the *muscle central.* The ventralmost of the two bundles is inserted, for the most part, below the inter-segmental articulation, and must therefore act as a flexor: it may be called the *oblique flexor.*

The enveloping muscles are, as already stated, paired, those of the right and left sides being distinct, but at about the middle of each segment there is a strong transverse band, covered by a shining aponeurotic sheath, passing between the enveloping muscles of the right and left sides. This is the *transverse muscle* of Milne-Edwards. In the fifth and sixth segments the aponeurotic band is of great width, extending, beyond the transverse muscle, from the middle of the fourth to the middle of the sixth segment.

From each side of the transverse muscle of the first three segments there springs a narrow cylindrical band which passes outwards and slightly forwards and is inserted, along with the oblique extensor, into the tergum: we propose to call it the *accessory oblique extensor.*

Where the main ventral muscles are exposed from beneath by removal of the sterna and inter-sternal membranes and of the superficial flexors, there is seen on each side of the middle line of the second to the sixth segments a flat, slightly divergent band, inserted into the sternum near the middle line, and obviously acting as the main flexor. It is the *muscle fléchisseur principal* of Milne-Edwards, and may conveniently be distinguished as the *longitudinal flexor.* It is rather small and indistinct in the sixth segment: its representative in the first will be described hereafter.

Immediately external to each longitudinal flexor is an oblique band of muscle, the fibres of which take a somewhat wavy course: this is the ventral portion of the

outer limb of the enveloping muscle, and constitutes what we propose to call the *external flexor* of the segment into which it is inserted : it is connected by a narrow ligamentous band with the longitudinal flexor of the segment next in front, and from it the oblique flexor arises. By pressing the longitudinal flexors aside the transverse muscles are seen as well from below as from above.

Anteriorly the ventral muscles are continued into the thorax by numerous bands arising partly from the inner surfaces of the epimeral plates, partly from the maxillary apodeme or foremost bar of the endophragmal system. They act, for the most part, as flexors of the first abdominal segment, and may be called the *thoracico-abdominal muscles*, the separate slips being most conveniently distinguished by numbers.

A large two-headed slip (1) arises from the maxillary apodeme; a second (2), also double-headed, arises by an inner head (2′) from the maxillary apodeme, by an outer head (2″) from the epimeron of the third thoracic segment ; a third (3) arises from the third thoracic epimeron, a fourth (4) from the maxillary apodeme, a fifth (5) from the third thoracic epimeron, and a sixth (6) from the fourth epimeron, *i.e.*, that corresponding to the first leg. All these unite to form a sheet of muscle partially divisible into longitudinal strands which are inserted into the first abdominal sternum. They therefore constitute the longitudinal flexor of the first segment. The innermost ventral strands, formed mainly from Nos. 1, 4 and 5, exhibit faint transverse tendinous intersections, and No. 2 unites with its fellow of the opposite side just ventrad of the thoracic transverse muscle.

Finally a seventh slip (7) arises by two heads (7′ and 7″) from the epimeron of the fifth thoracic segment and divides into three bundles. One of these (7^a) joins the slips mentioned in the preceding paragraph, becoming the outermost strand of the longitudinal flexor of the first abdominal segment; the second (7^b) passes below the thoracic transverse muscle, and, as will be seen hereafter, joins the transverse muscle of the first abdominal segment; the third (7^c), placed dorsally, passes distinctly backwards and is encircled by the thoracic enveloping muscle. As will be seen this latter bundle is the commencement of the central muscle of the abdomen, presently to be described.

The greater part of the foregoing descriptions can be verified without the severance of a single muscle ; to make out the connection of the various bands with one another it is necessary to cut and reflect the superficial ones.

When the enveloping muscles of the thorax and of the first five abdominal segments are cut through by a longitudinal incision and reflected, each is seen to wrap round a curved cylindrical band, the *central muscle* of Milne-Edwards. This turns dorsad at its anterior end and, emerging between its own enveloping muscle

and that of the preceding segment, forms the oblique extensor already referred to (p. 162).

The central muscles are all connected together by some of the fibres of one passing into the next, and the first, as already mentioned, arises from the thoracic slip No. 7. Thus the whole series of central muscles forms a continuous wavy longitudinal band extending from the thorax to the end of the abdomen, and sending off slips, acting as extensors, to the six anterior abdominal segments.

After being cut and reflected the enveloping muscle is easily traced. In such a typical segment as the third its outer limb bends round the pleural region, reaches the ventral aspect, and is connected by an aponeurosis with the longitudinal flexor of the segment next in front, forming the external flexor already noticed: before passing into the aponeurosis it gives origin to the diverging bundle of fibres already noticed as the oblique flexor. The inner limb turns downwards, parallel with its fellow of the opposite side, and then sweeps backwards and becomes the longitudinal flexor of the next following segment but one.

The enveloping muscle of the thorax takes a different course: its inner limb is normal, becoming the longitudinal flexor of the second abdominal segment; but its outer limb divides into two bundles, one of which passes into the transverse muscle of the thorax and so becomes continuous with its fellow of the opposite side, while the other sweeps backwards and inwards, round the central muscle, and joins the transverse muscle of the first abdominal segment.

Two other enveloping muscles present peculiarities: the outer limb of that of the first abdominal segment goes to the sternum of its own segment instead of that next in front; and the inner limb of that of the fifth segment goes to the sternum of the sixth.

The transverse muscles of the abdominal segments are for the most part made up of three strands, best seen in the third and fourth segments. One strand is antero-dorsal in position and is formed by the union of fibres from the right and left central muscles of the segment next in front: another is antero-ventral and springs from the inner limbs of the enveloping muscles of the segment next in front: the third is posterior and somewhat dorsal in position and is derived from the central muscles of the segment itself.

In the first segment the transverse muscle consists of three portions, two of which have been referred to separately. The dorsal portion is normal, springing from the central muscle; the middle portion is derived from the outer limb of the thoracic enveloping muscle; the ventral portion springs from slip No. 7 of the thoracico-

abdominal muscles. In the second segment the slip from the enveloping muscle of the preceding segment is absent. In the fifth and sixth segments the three factors are so closely united as to form a single band.

In the third, fourth and fifth segments the longitudinal flexor is reinforced by a narrow slip springing from the mesial aspect of the central muscle of the segment next in front: this may be called the *internal accessory longitudinal flexor.*

In the third and fourth segments there is also an *external accessory longitudinal flexor* arising from the central muscle of the segment next but one in front, and inserted with the external flexor into the sternal aponeurosis.

The telson is depressed by a single muscle on each side, which arises from the fifth sternum and sends off a lateral slip to the basipodite of the sixth abdominal appendage. It lies dorsad of the flexor muscles of the lateral tail-lobes.

Thus any typical abdominal segment, such as the third, is acted upon by the following muscles :—

1. A pair of *superficial extensors*, situated in the segment next in front and inserted into the anterior border of the tergum near the middle line.

2. A pair of *deep extensors,* situated in the segment next in front, beneath the preceding, and inserted into the anterior border of the tergum near the middle line.

3. A pair of *oblique extensors,* derived mainly from the central muscle of the segment itself but partly also from that of the preceding segment, and inserted into the tergum immediately above the peg-and-socket joint.

4. A pair of *accessory oblique extensors,* arising from the transverse muscle of the segment itself.

5. A pair of *superficial flexors,* situated in the segment next in front and inserted into the sternum a short distance from the middle line.

6. A pair of *longitudinal flexors,* arising from the inner limbs of the enveloping muscles of the segment next but one in front and inserted into the sternum near the middle line.

7. A pair of *internal accessory longitudinal flexors,* arising from the central muscle of the segment next in front and inserted with the preceding.

8. A pair of *external flexors,* arising from the outer limbs of the enveloping muscles of the segment next behind and joining the insertions of the longitudinal flexors by an aponeurotic band.

9. A pair of *external accessory longitudinal flexors*, arising from the central muscle of the segment next but one in front and inserted with the preceding.

10. A pair of *oblique flexors*, arising from the external flexors of the segment next in front.

We thus arrive at the remarkable result that a typical segment in the abdomen of a macrurous crustacean has no fewer than ten pairs of muscles or muscular slips concerned in the simple movements of flexion and extension, of which alone it is capable.

The following segments present variations from the typical arrangement just described :—

1st segment.

1. The superficial extensor arises from the tergal region of the carapace.
2. The deep extensor arises by five slips from the epimeral plate of the thorax.
3. The superficial flexor arises from the sternal region of the thorax between the seventh and eighth segments.
4. The place of the longitudinal flexors is taken by the thoracico-abdominal muscles which arise partly from the maxillary apodeme, partly from the epimeral plates.
5. The oblique flexors and the accessory longitudinal flexors are absent.
6. An additional external flexor is furnished by the outer limb of the enveloping muscle of the segment itself.
7. The transverse muscle consists of three strands, one derived as usual from the central muscle, one from the outer limb of the thoracic enveloping muscle, and the third from slip No. 7 of the thoracico-abdominal muscles.

2nd segment.

1. The longitudinal flexor is constituted by the inner limb of the enveloping muscle of the thorax.
2. There are no accessory longitudinal flexors.
3. The transverse muscle does not receive a slip from the enveloping muscle of the preceding segment.

4. The external flexor is reinforced by a band from slip No. 6 of the thoracico-abdominal muscles.

5th segment.

1. There is an additional longitudinal flexor furnished by the inner limb of the enveloping muscle of the fourth segment.

2. The accessory oblique extensor, the external accessory longitudinal flexor, and the external flexor are absent.

6th segment.

1. The superficial and accessory oblique extensors, and the accessory longitudinal, oblique, external, and superficial flexors are absent.

2. The longitudinal flexor is furnished from the inner limb of the enveloping muscle of the fifth segment.

7th segment (telson).

The only axial muscles connected with the telson are a pair of deep extensors and a pair of flexors arising from the sternum of the fifth segment.

The lateral muscles of the abdomen consist of a single muscle (fig. 4) on each side called by Howes the *levator abdominis.* In our opinion the action of this muscle is more accurately expressed by calling it a rotator. We have observed in the living animal that the abdomen can be rotated, as a whole, upon the cephalothorax, this movement being rendered possible that there are no articulations between the posterior end of the thorax and the first abdominal segment, the two being connected merely by the loose thoracico-abdominal membrane.

The *rotator abdominis* is a large three-headed muscle. The larger head arises from the inner surface of the carapace just posterior to the cervical groove, and above the branchio-cardiac groove. The middle head arises from the dorsal edge of the epimeral plate in the region of the seventh thoracic segment. The short head arises from the epimeral plate just below and behind the preceding. The three heads unite into a single tendon, which is inserted into a small sclerite* connected with the anterior border of the first abdominal segment.

Acting together these muscles must draw the abdomen forwards, at the same time raising it slightly : acting separately they obviously act as rotators, each raising

* Marked *a* in Huxley's "Crayfish," fig. 38, and representing part of what Howes ("Atlas") calls the "Thoraco-abdominal linkwork" in Astacus.

the lateral region of the first abdominal segment of its own side. This latter movement may be assisted by the thoracic portions of the deep extensors, each of which, acting separately, would supplement the action of the rotator of the opposite side.

2. *Muscles of the cephalothorax.*

Owing to the concrescence of the cephalothoracic segments the muscles of this region are greatly reduced. They are, in fact, represented only by numerous more or less parallel fibres passing from the inner surface of the cervical groove to the inner surface of the anterior and dorsal regions of the epimeral plates (fig. 10). These fibres are described but not named by Huxley ; we propose to call them the *tergo-epimeral muscles.* Their action must be to effect a slight approximation of the carapace to the sterno-epimeral region of the thorax.

II. THE APPENDICULAR MUSCLES.

The general arrangement of the intrinsic limb-muscles is well known, although often inadequately described. The typical arrangement is that each podomere or limb-segment is acted upon by two muscles situated in the preceding or next proximal podomere. The muscles are usually of unequal size, the larger being a flexor, the smaller an extensor. Both are bipinnate, their fibres arising from opposite sides of the segment in which they occur and passing obliquely into opposite sides of a strong chitinized or partially calcified tendon. The extensor tendon is inserted into the proximal edge of the podomere upon which it acts, on the extensor side, half-way between the two peg-and-socket joints. The flexor tendon is similarly inserted on the opposite or flexor side, so that a straight line joining the two insertions is at right angles to one joining the two articulations. This arrangement is shown in fig. 12, which represents the muscles of the fourth leg.

The extrinsic limb-muscles, however, *i.e.*, those which arise from the axial exoskeleton and move the appendage as a whole, vary considerably in the different kinds of limb.

1. *Extrinsic muscles of the legs* (figs. 13-17).

The two proximal podomeres of the leg—the coxo- and basipodite—are so short that the muscles acting on them may be considered as moving the limb as a whole. In accordance with the mode of articulation of these segments the flexor of the coxopodite acts as an adductor of the entire leg, its extensor as an abductor, the flexor of the basipodite as a levator, its extensor as a depressor.

The muscles of the coxopodite arise entirely and those of the basipodite in part from the corresponding compartment of the endophragmal system. The compartment is bounded in front by what may be called its anterior endosternite, endopleurite, and arthrophragm, *i.e.*, the plates so called* separating the segment in question from its immediate predecessor; and behind by the posterior endosternite, endopleurite, and arthrophragm, which similarly separate it from the next following compartment. An oblique plate passes from the anterior endopleurite to the posterior endosternite and partly divides the compartment into two chambers—one antero-mesial, the other postero-lateral.

The *abductor* of the leg is a two-headed muscle: the outer head arises partly from the epimeron, partly from the anterior endopleurite; the inner head arises from the posterior endosternite. The fibres of the two heads pass to opposite sides of the tendon which is inserted into the proximal edge of the coxopodite on its posterior aspect, just behind the place of origin of the podobranchia.

The *adductor* of the leg is also two-headed. Both heads arise from the anterior endosternite, and the single short tendon into the anterior side of the proximal edge of the coxopodite.

The *levator* of the leg has a long and a short head. The long head arises from the posterior endosternite, the short head from the dorsal region of the coxopodite. The tendon is inserted into the dorsal side of the proximal edge of the basipodite.

The *depressor* of the leg also has a long and a short head. The long head arises from the posterior endosternite, the short head from the postero-ventral region of the coxopodite. The strong forked tendon is inserted into the ventral region of the proximal edge of the basipodite.

The muscles of the maxillipedes resemble those of the legs except in detail. The abductor and adductor of the exopodite are lodged in the basipodite.

2. *Extrinsic muscles of the swimmerets* (fig. 18).

The forward movement of the swimmeret is performed by a double-headed extensor which arises from the pleuron and is inserted into the basipodite. The backward movement is done by a single large fan-shaped flexor which arises from the pleuron just above the extensor and is inserted into the basipodite. The absence of articulations to the swimmerets probably allows of a feathering movement during the forward stroke.

* See Huxley, "The Crayfish," p. 158.

3. *Muscles of the tail fin* (figs. 8 and 9).

The numerous muscles of the tail fin may be arranged in four groups as follows:—

a. Axial muscles of the telson. These have been already described (p. 167).

b. Extrinsic muscles of the lateral tail-lobes or appendages of the sixth abdominal segment: these are divisible into flexors and extensors.

c. Adductor muscles of the tail fin, passing between the telson and the lateral tail-lobes and serving to approximate the various parts of the tail fin during the back-stroke.

d. Muscles of the endo- and exopodites.

Flexor of the lateral tail-lobe. There are no fewer than five well-marked muscular bands serving to depress each lateral tail-lobe, but as they are all inserted by a single tendon they are best considered as five heads of one and the same muscle.

The *dorsal head* is a conical muscle arising from the middle region of the sixth abdominal tergum: the *ventral head* is a large flat band arising from the fifth sternum and passing backwards and outwards so as largely to cover the longitudinal flexor of the sixth segment in a view from beneath: the *posterior head* arises from the sixth sternum: the *external head* arises from the fifth sternum laterad of the ventral head: the *accessory head* is a branch of the flexor of the telson. All five heads unite in a strong tendon which is inserted into the proximal edge of the basipodite near the middle of its ventral side.

The *dorsal extensor of the lateral tail-lobe* arises from the sixth tergum immediately caudad of the dorsal head of the flexor, and is inserted by a distinct tendon into the dorsal surface of the proximal edge of the basipodite.

The *external extensor of the lateral tail-lobe* arises from the sixth pleuron and passes directly backwards to be inserted by a distinct tendon immediately in front of the preceding.

The *long adductor of the tail fin* arises by two heads from the tergum of the telson; the origin is an extensive one, occupying about the anterior half of the tergum. The muscle is inserted into the arthrodial membrane uniting the basipodite of the lateral tail-lobe with the sternum of the sixth abdominal segment.

The *middle adductor of the tail fin* arises from the tergum of the telson immediately in front of the inner head of the preceding; it is inserted into the flexor tendon of the lateral tail-lobe.

The *short adductor of the tail fin* arises from the outer corner of the anterior edge of the tergum of the telson, and is inserted into the ventral edge of the basipodite of the lateral tail-lobe immediately caudad of the flexor tendon.

The *external abductor of the exopodite* arises from the anterior face of the basipodite, and is inserted into the outer corner of the proximal edge of the exopodite.

The *long abductor of the exopodite* arises from the dorsal region of the proximal border of the basipodite, and has an extensive insertion into the dorsal plate of the exopodite.

The *internal abductor of the exopodite* arises from the ventral surface of the basipodite, and is inserted into the dorsal surface of the proximal border of the exopodite.

The *ventral adductor of the exopodite* arises from the ventral surface of the basipodite towards its mesial side, and passes obliquely upwards and outwards to its insertion in the dorsal plate of the exopodite near its proximal end.

The *long adductor of the exopodite* arises from the middle of the dorsal surface of the basipodite, and has an extensive insertion into the dorsal plate of the exopodite.

The *short adductor of the exopodite* arises from the dorsal surface of the basipodite, and is inserted into the ventral region of the proximal edge of the exopodite.

The *adductor of the endopodite* arises from the middle of the dorsal surface of the basipodite and has a long insertion into the dorsal plate of the endopodite.

4. *Extrinsic muscles of the second maxilla* (fig. 20).

The extrinsic muscles of the second maxilla are of great size, considering the dimensions of the appendage itself: they act upon the scaphognathite and are therefore to be looked upon as the chief respiratory muscles.

The *protractors*, or muscles which draw the scaphognathite forwards and inwards, are two long parallel-sided bands arising from the cephalic apodeme and inserted into the basal region of the appendages. They are opposed by a *long retractor* which arises from the maxillary sternum, and by a fan-shaped, two-headed, *short retractor* which arises at the junction of the maxillary sternum with the cephalic apodeme.

5. *Extrinsic muscles of the first maxilla* (fig. 19).

The peculiar sifting movements of the first maxilla are performed by four adductor slips arising from the cephalic apodeme, and by a very distinct abductor, in

the form of a conical muscle arising from the carapace behind and below the origin of the long adductor of the mandible, and inserted by a long slender tendon into the external aspect of the basal region of the appendage.

6. *Extrinsic muscles of the mandible* (figs. 8 and 10).

The *long adductor* is a large conical muscle arising from the dorso-lateral region of the carapace a short distance cephalad of the cervical groove; it is inserted by a long calcified tendon into the postero-internal angle of the mandible.

The *short adductor* is a small fan-shaped muscle arising from the cephalic apodeme and radiating outwards from its origin to a wide fleshy insertion on the inner or concave side of the mandible.

The *external adductor* has an extensive origin from the inner surface of the carapace anterior to the cervical groove; its short fibres pass directly mesiad to their broad fleshy insertion on the outer edge and adjacent part of the ventral or convex surface of the mandible.

The *long abductor* is a band-like muscle arising from the cephalic apodeme and passing outwards and forwards to its insertion in the antero-external angle of the mandible.

The *short abductor* arises from the lateral surface of the cephalic apodeme, its fibres diverging to their insertion in the posterior edge of the mandible.

7. *Muscles of the antenna* (figs. 8, 10, 24, and 25).

The antennæ of Palinurus are remarkable for their great size and for the fact that their proximal podomeres (coxopodites) have concresced with one another and with the carapace to form a flat horizontal plate, the *pseudepistoma*, on which the renal apertures are situated. It has been pointed out by one of us* that the adjacent or mesial walls of the coxopodites are represented by the vertical, two-layered *internal coxal plate* which projects inwards (dorsad), in the middle line, from the pseudepistoma, while their lateral walls are represented by the oblique *external coxal plates* which project inwards, in like manner, at the junction of the pseudepistoma with the carapace.†

Connected with the pseudepistoma and the coxal plates are certain ligaments and functionless muscles which we consider to be the degraded representatives of the muscles by which the coxopodites were moved in the ancestors of the genus.

* Parker, "On the Structure of the Head in Palinurus." Trans. N.Z. Inst. Vol. XVI. 1883, p. 297.

† It is quite possible that the coxal plates represent, not portions of the coxopodite itself, but the insertions of calcified tendons which have become hypertrophied in order to serve as points of origin for the great antennary muscles.

Attached to the upper border of the external coxal plate is a strong but slender ligament which passes upwards and slightly forwards and outwards to be attached to the lower border of a strong sheet of fibrous tissue lining the prostomial plate. We propose to call this the *anterior coxal ligament*, and consider it to be the vestige of a muscle which rotated the coxopodite inwards.

Attached to the posterior border of the external coxal plate is a similar but shorter ligament which passes backwards and inwards to unite with the cephalic apodeme. We call this the *posterior coxal ligament*: it probably represents a muscle which assisted the action of the preceding, or the two may have been the distinct heads of a single muscle the tendon of insertion of which has now become the external coxal plate.

Inserted into the upper edge of the internal coxal plate is a strong, slender, median ligament which passes upwards and slightly forwards into the apex of a pyramidal mass of muscle, the expanded base of which arises from the carapace and adjacent parts. This muscular cone is readily separable into two portions: the anterior part will be described hereafter as one of the muscles of the eye-stalks, the posterior part is bipinnate and arises, on each side, by two heads, one from the prostomial plate just below the ophthalmic fenestra, the other from the anterior region of the carapace near the middle line. We call this muscle the *superior coxal muscle*, and its ligament the *median coxal ligament*: it probably served to rotate the coxopodite outwards.

The last of these interesting vestiges of a vanished musculature is a narrow band of muscle which arises from the carapace below the origin of the external adductor of the mandible, curves round the antero-external region of the mandible, and is inserted into the posterior edge of the pseudepistoma near its outer end. This *external coxal muscle*, although not reduced to ligament, must be quite functionless, since its ends are attached to two structures which are incapable of movement upon one another.

The coxopodite being fixed, the muscles which move the antenna as a whole are those of the basipodite. The axis of articulation is oblique, so that its two movements are a combination of elevation with abduction and of depression with adduction. We shall speak of the muscles as levators and depressors.

The *superior levator* arises from the inner surface of the carapace just above the origin of the external adductor of the mandible. Its fibres converge into a strong calcified tendon which is inserted into the dorsal region of the proximal edge of the basipodite.

The *inferior levator* is a large cylindrical muscle arising from the outer surface of the external coxal plate and inserted, without a tendon, into that portion of the proximal border of the basipodite which is bounded above by the tendon of the superior levator and below by the infero-lateral hinge. The portion of the basipodite to which this muscle is attached is thickened and serrated for its insertion.

The *depressor* is a large two-headed muscle. The outer head arises from the inner surface of the external coxal plate, the inner head from the internal coxal plate: the two heads unite in a large calcified tendon which is inserted into the mesio-ventral corner of the proximal edge of the basipodite.

The *ischiopodite*, or third podomere of the antenna, has three muscles, two levators and a depressor, all arising from the basipodite. The surface of origin of the depressor is increased by the inflection of part of the ventral region of the proximal border of the basipodite in the form of a small upstanding plate situated immediately laterad of the insertion of the depressor tendon described in the preceding paragraph.

8. *Extrinsic muscles of the antennule* (figs. 21-23).

The articulation of the antennule is quite different from anything we have met with or seen described in the Arthropoda. This appendage is attached to the ventral end of the *inter-antennulary bar*, a strong vertical plate connecting the prostomial plate *(vide infra)* with the pseudepistoma. The basal podomere of the antennule is connected with its articular cavity by a very wide arthrodial membrane which extends all round the joint, there being no peg-and-socket articulations visible externally. Movement is possible in all planes, but, contrary to what would be expected from the extent of the arthrodial membrane, the antennule cannot be pulled in and out but always remains at a constant distance from its articular cavity.

The explanation of this peculiarity is as follows:—The mesial border of the articular cavity is produced into a strong calcified peg which passes downwards, outwards and forwards, so as to project into the base of the antennule. A similar peg arises from the dorsal surface of the first segment of the antennule, near its proximal edge, and passes backwards and downwards, its apex coming in contact with that of the previously mentioned peg and articulating with it. In this way an internal articulation is produced, allowing of universal movement.

The muscles of the antennule present very striking peculiarities. The appendage is raised by a long *levator* which arises from the infra-ophthalmic bar of the prostomial plate *(vide infra*, p. 175), and is inserted by a calcified tendon into the arthrodial membrane on its dorsal side. There is a small *abductor* arising from the inwardly projecting lateral edge of the inter-antennulary bar, and an *adductor* arising from the middle region of the bar: both are inserted into the arthrodial membrane.

The antennule is further acted upon by two muscles which, unlike those of the other appendages, are continuous through the three podomeres, and may be conveniently called the *internal* and *external long antennulary muscles.* The external muscle arises by a calcified tendon from the arthrodial membrane close to the ventral edge of the articular cavity: the internal has a similar origin from the dorso-mesial aspect of the articular cavity. The external muscle is closely connected at its origin with the abductor, the internal with the adductor. Both muscles extend distad and send off slips to the proximal edges of the second and third podomeres and of the two flagella. In the middle of the proximal podomere their fibres are intermingled. The internal muscle seems to act as a combined adductor and levator of the antennule as a whole, the external as a combined abductor and depressor. Each flagellum is further acted upon by a small muscle which apparently serves as an adductor.

Thus the muscles of the antennule resemble those of the abdomen rather than those of a typical appendage, since there are continuous bands extending through the whole appendage, arising from a fixed structure and sending off slips into the movable parts.

9. *Muscles of the eye-stalks* (fig. 25).

The eye-stalks are attached to the *prostomial plate,* a concave structure over-arched by the rostrum and the supra-orbital spines, and continuous externally with the carapace proper: its ventral border forms the dorsal edge of the articular cavity of the antenna, and the inter-antennulary bar is continuous with its mid-ventral region. It is perforated in the middle by a large transversely oval aperture, the *ophthalmic fenestra,* which forms the articular cavity for both eye-stalks, their loose arthrodial membrane being attached to its edges. The portion of the prostomial plate above this aperture is the *supra-ophthalmic bar;* it gives origin to the procephalic processes and is continuous with the ventral plate of the rostrum: the portion below the aperture is the *infra-ophthalmic bar,* and gives origin to the clasping processes which embrace the rostrum laterally. The whole prostomial plate is lined by a strong sheet of ligament which, as already mentioned, gives origin to the anterior coxal ligament, and which is continued below into a chiasma-like arrangement of fibres connected with the inter-antennulary bar and covering the dorsal ends of the levator muscles of the antennules.

The arthrodial membrane of the eye-stalks is calcified dorsally by a small median sclerite having the form of a half cylinder, and hidden in the entire animal by the rostrum to the concave ventral surface of which it is closely applied. A short distance on either side of this *inter-ophthalmic sclerite* the arthrodial membrane is continued into the eye-stalk which consists of a small *basal sclerite,* incomplete below, and of the strongly calcified *distal sclerite* or eye-stalk proper.

The eye-muscles are inserted partly into the inter-ophthalmic sclerite, partly into the basal sclerite, and partly into the eye-stalk itself.

The *depressor of the inter-ophthalmic sclerite* is a large bipinnate muscle arising from the median coxal ligament, and passing upwards in front of the superior coxal muscle to a double insertion in the inter-ophthalmic sclerite. This muscle depresses the eye-stalks and at the same time rotates them slightly backwards.

The *levator of the basal sclerite* arises from the inter-ophthalmic sclerite and passes across the dorsal region of the arthrodial membrane to be inserted into the basal sclerite.

The *rotator of the basal sclerite* arises from the infra-ophthalmic bar of the prostomial plate in common with the depressor of the eye-stalk : it is inserted into the posterior edge of the basal sclerite and produces a backward rotation of the eye-stalk.

The eye-stalk contains four small straight muscles which surround the optic nerve and ganglion and are all inserted into the distal region immediately proximad of the cornea. Of these one is dorsal, arises from the basal podomere and acts as a *levator:* the other three arise from the prostomial plate, the anterior one being an *abductor*, the posterior an *adductor*, and the ventral a *depressor* of the eye-stalk.

SUMMARY.

1. The great ventral mass of muscle in the abdomen, usually considered to act exclusively as a flexor, gives rise to slips which, being inserted into the terga of the segments above the hinges, and pulling in an almost horizontal direction, must act as extensors.

2. The ventral (so-called flexor) muscles of the abdomen exhibit far greater complexity than would be gathered from Milne-Edwards' description of the muscles of *Homarus*. We have found it necessary to make numerous additions to the terminology, as it was hardly possible to describe the various flexor and extensor slips without giving them appropriate names. A list of the slips inserted into a typical abdominal segment is given on p. 163. (See also diagrams, Pl. XXI.)

3. The muscle usually called levator abdominis is more accurately called a rotator, since it is the chief agent in rotating the abdomen as a whole upon the cephalothorax.

4. The muscles of the tail fin are very complex, several bands passing between the telson and the lateral tail-lobes, and so serving to approximate the parts of the fin during extension of the abdomen.

5. The mandible is acted upon by three adductors and two abductors.

6. Two pairs of muscles and two pairs of ligaments probably formed by the degeneration of muscles, are described passing between the axial skeleton and the pseudepistoma or fused coxopodites of the antennæ.

7. The antennule has a unique form of articulation allowing of movement in all directions. It contains two muscles, their fibres partially united, which arise from the axial skeleton and extend through the whole length of the appendage, sending slips to the various podomeres. The musculature of the antennule thus resembles that of the abdomen rather than that of the other appendages.

DESCRIPTION OF PLATES.

Plate XVII.

Fig. 1.—Two abdominal segments with the terga removed to show the extensor muscles: in the lower segment the superficial extensors are removed.

Fig. 2.—Two abdominal segments with the intersternal membrane removed to show the superficial flexors.

Fig. 3.—Three abdominal segments with the exoskeleton removed from the left side to show the insertions of the oblique extensors and flexors.

Fig. 4.—Adjacent portions of the cephalothorax and abdomen, showing the rotator muscle and the insertions of the oblique extensors and flexors: the outline of the central muscle is dotted.

Fig. 5.—Frozen sections through the thorax.

Figs. 6 and 7.—Two frozen sections through the abdomen.

Plate XVIII.

Fig. 8.—Dissection of the ventral muscles of the abdomen as exposed by the removal of the dorsal muscles, enteric canal, &c. On the left side portion of the enveloping muscles is removed to show the centrals. In the upper part of the figure the muscles of the antennæ, mandibles, &c., are shown.

Fig. 9.—Dissection of the ventral muscles of the abdomen from beneath. On the left side the longitudinal flexors are partly cut away so as to expose the transverse muscles, and the oblique flexors are displaced.

PLATE XIX.

Fig. 10.—Sagittal section of the body, showing the muscles of the abdomen, antenna, mandible, &c.
Fig. 11.—The same, with portions of the enveloping muscles removed.

PLATE XX.

Fig. 12.—Intrinsic muscles of the fourth leg.

Figs. 13-17.—Extrinsic muscles of the same, posterior aspect: fig. 13, after removal of the fifth leg; fig. 14, after removal of the endosternite and arthrophragm; fig. 15, after removal of the posterior wall of the coxopodite; fig. 16, after removal of the abductor and depressor; fig. 17, after removal of the levator.

Fig. 18.—Muscles of a swimmeret (male).

Fig. 19.—Muscles of the first maxilla.

Fig. 20.—Muscles of the second maxilla: the adductor and long abductor are removed on the right side.

Fig. 21.—Muscles of the right antennule, from the outer side.

Fig. 22.—The same after removal of the abductor and external long antennulary muscles.

Fig. 23.—The articulation of the left antennule as exposed by the removal of the muscles from the outer side.

Fig. 24.—The anterior region of the head, seen from within, showing the extrinsic muscles of the antennule, &c.

Fig. 25.—A similar dissection (twice natural size), showing the ophthalmic muscles.

PLATE XXI.

Fig. 26.—Diagram of the abdominal muscles in the form of a sagittal section.

Fig. 27.—Diagram of the ventral muscles of the abdomen, dorsal aspect.

OBSERVATIONS UPON THE ANATOMY OF THE MUZZLE OF *ORNITHORHYNCHUS*.*

By J. T. Wilson, M.B., Professor of Anatomy, University of Sydney, and C. J. Martin, M.B., B.Sc., Demonstrator of Physiology, University of Sydney.

(Plates xxii.-xxiii.)

The term "duck-bill" as commonly applied to the muzzle of the Platypus seems to have been the source of a certain degree of misconception in regard to the characters of that portion of the animal, not merely on the part of the unlearned multitude but of not a few eminent comparative anatomists.

This so-called "duck-bill" is described by Huxley (1) as "a flattened muzzle resembling the beak of a duck." This quite correctly expresses the form and general appearance of the muzzle, but the integument is by no means "leathery" as this author terms it. Owen (2), too, speaks of the lips as "transitorily manifested, it is true, at the suckling period, but which soon degenerate into the pergameneous border of the beak," and again (p. 384) "the jawbones are invested by a smooth coriaceous integument." Such terms as "leathery," "pergameneous" and "coriaceous" are inappropriate and misleading, but they are certainly less so than the term "horny" which is used by some other authors.

Thus, Flower (3) speaks of the premaxillæ as supporting the "partly horny partly membranous beak which fills up the space between them and extends considerably on each side and in front." Mivart, too (4), in his chapter on the "external skeleton," writes thus :—"The epidermis of the outside of the muzzle and jaws may also be converted into horn as in the beak of birds and in that of the turtle. As a remarkable exception, the same thing may take place in man's own class : this we see by the duck-billed Platypus, which really has a horny beak very like that of a duck."

As a matter of fact, the epidermis of the muzzle of Platypus is no more "horny" than that of a dog's nose, from the texture of which indeed it does not greatly differ.

The sole explanation intelligible to us of such applications of the epithet "horny" to the skin of the muzzle of Platypus is that the statements have been based upon an examination of preserved specimens which had undergone partial desiccation—which

* An abstract of this paper was published in the Abstract of Proceedings of the Linnean Society of N.S.W., August 31st, 1892.

indeed pretty rapidly occurs in the unprotected skin of the snout. In the living, perfectly fresh specimen the skin is not even "leathery" or "pergameneous," like that of the duck, but on the contrary is, as Waterhouse (5) described it, "naked skin"—"uniformly smooth and flexible"—not only at the free margins or lip-folds but throughout the whole extent of the muzzle. This integument is not even remarkably thick as the latter author's description elsewhere implies, since the epidermal layer averages about 0·4 mm.

In the living animal the whole muzzle, including both upper and lower jaws, is covered by smooth soft and humid skin, pigmented over the whole dorsal aspect of the muzzle, but pale or almost white on the ventral aspect. Both on the upper and lower jaws the skin-covering extends beyond the limits of the osseous facial skeleton, forming free flexible upper and lower lips bounding the entire gape.

These lips, however, do not consist of skin folds only, but, as will presently be seen, they possess a cartilaginous skeletal basis, and in this latter respect, certainly, they differ from true lip-folds. It will be convenient, however, to continue to refer to them as the lips of the animal.

It is unnecessary to enter into any detailed description of the osseous skeleton of the jaws as the anatomy of the dried adult skull is adequately given in the various text-books which deal with the subject. But the cartilaginous basis of the lips forming a marginal extension of the skeleton of both upper and lower jaws is completely ignored by some writers, though noticed and figured by Meckel (6) and subsequently by Owen (7) and by W. K. Parker (8). The latter author, indeed, has fully recognised the importance of the arrangement in question, but we believe that its true significance in the morphology of the skull of the animal has been hitherto entirely overlooked, and indeed we are unaware that any author except Parker has inquired into the question.

The skeletal basis of the upper lip forms a strip of cartilage, which averages about a centimetre in breadth, and is intimately adherent laterally and in front to the free margins of the maxillæ and premaxillæ, which are slightly grooved for its better attachment. Its lateral part extends backwards as far as the lateral projection of the maxilla which overhangs the antorbital foramen and is attached to that process opposite the opening of the foramen, so that some of the nerve bundles issuing from it pass superior and some inferior to the cartilage, lying between it and the skin above and below to which they are distributed.

The corresponding cartilage in the lower lip forms a somewhat similar strip attached to the anterior divergent ends of the rami of the mandible, but it has a more limited lateral and backward extension than that in connection with the upper jaw, while, as will presently be pointed out, it also differs structurally from the latter.

Since Parker's views represent the sole extant interpretation of these structures we shall quote his words for purposes of discussion.

Referring to the so-called "duck-bill," he says :—"Much as it resembles the beak of a duck its structure is widely different . . . [the bones] do not, as in the duck, finish the margins of the beak, for in that bird, as in its congeners, the bones of the upper face run close to the quick that secretes the bony sheath. But the duck-billed mammal is quite unique ; the whole outline of the great rostrum is formed by a large sheet of solid hyaline cartilage right and left. This extraordinary growth of true cartilage in the extended upper lip is quite similar to the growth in the lower lips of mammals generally, viz., that slab of cartilage on which the dentary bone grafts itself to form the bulk of the solid maxilla inferior." And he further proceeds—"We have to go down amongst the lower cartilaginous fishes for similar outgrowths of superficial cartilage in the region of the mouth."

It is not quite clear from the above quotation whether in Parker's view the marginal cartilage of the lower lip of Platypus is, or is not, actually the free marginal portion of that "slab of cartilage" upon which the dentary has grafted itself. We miss, indeed, any special reference to the inferior marginal cartilage of the mandible of the adult Platypus on the part of this author. That cartilage, however, though analogous in position and function to the cartilaginous basis of the upper lip, we find to be essentially different from it, in that it consists only of white fibro-cartilage and thus probably possesses no very special morphological importance.

The strip or sheet of cartilage bordering the upper jaw, on the other hand—the "large valance of solid cartilage" as Parker graphically calls it—is composed of true hyaline cartilage, and we believe it to have a structural meaning not only different from that of the inferior marginal cartilage but wholly different from that suggested by Parker.

If our interpretation of it be correct we have not only *not* to "go down amongst the lower cartilaginous fishes" for an explanation of it, but we need not even go beyond the pale of the class mammalia to find a key to the solution of this structural puzzle.

The observations which have yielded the results embodied in this paper have been carried on both by means of dissections, and by the study of series of coronal sections of the snouts of adult animals. We regret that, as yet, we have been unable to amplify and corroborate our conclusions by the aid of observations upon young and developing specimens, but we believe that, so far as they go, the conclusions arrived at will be found sufficiently definite and intelligible to justify their publication.

The dorsal aspect of the anterior part of the facial skeleton of *Ornithorhynchus* is characterised by the presence of diverging "rostral crura," as we propose to call them

throughout this paper, consisting chiefly of the premaxillary bones which turn inwards abruptly in front—forceps-like—to limit the bony rostrum anteriorly, while, in the hinder part of each crus, the premaxilla is wedged in between, and supported by, the splint-like forward (rostral) prolongations of the nasal and superior maxillary bones, internally and externally respectively.

A very extensive open gap which we may call "inter-crural" is thus included between these rostral crura. This interval is open in front between the forceps-like points which do not approximate very closely to one another. Viewed from the dorsal aspect this interval narrows posteriorly into a mere notch between the nasal bones where it limits the incomplete bony anterior narial aperture which is partially divided by the incomplete bony septum.

Viewed from the ventral or palatine aspect (fig. 17) the same area is visible, open in front, and bounded laterally by the same diverging bony crura (of which, however, the nasal component is not here visible, being confined to the dorsal aspect), but truncated posteriorly because bounded by the abrupt, notched, anterior margins of the palatine processes of the superior maxillary bones. The presence of a notch on the anterior border of each palatine process gives rise to the appearance of a mesial tongue-like process projecting into the hinder angle of the wide inter-crural space. The anterior margin of this tongue of bone is abrupt and is in relation with the hinder end of the dumb-bell-shaped bone.

This so-called dumb-bell-shaped bone was originally regarded by Rudolphi (8), Meckel (9) and Owen (10) as the equivalent of an inner division of the inter-maxillary bones. Then Owen (11), followed by Flower (12), interpreted it as the homologue of the prenasal of the pig. But more lately Albrecht (13) and Turner (14) have shown that the original view is the more correct one, and this finding has been adopted by Flower and Gadow (15), and more recently confirmed by Symington (16).

The last-named author concludes that "the dumb-bell-shaped bone from its position in relation to the cartilages of the nose is evidently ossified in the membrane investing them."

With the exception of Symington, none of the authors referred to seems to have investigated the constitution and connections of the cartilaginous walls of the nasal cavities in this region with special reference to their intimate relation to the dumb-bell-shaped bone. Symington, indeed, has accurately described and figured the construction and disposition of the nasal cartilages in the immediate neighbourhood of the dumb-bell-shaped bone and has arrived at the conclusion quoted above from his work.

He has also stated in outline the constitution of the nasal capsules in front of the dumb-bell-shaped bone. There are, however, some points of importance in the

structure of the anterior part of the nose to which he has not referred and which render the anatomy of that region less simple than his account would suggest. And, further, his work does not refer to the anterior connections of the nasal cartilages, and the structural arrangements in the anterior part of the interval between the rostral crura.

Sir Wm. Turner (17), however, has referred to that interval as filled in by "fibrous membrane" "attached behind to the anterior free border of the palate plate of each inferior maxilla, at each side to the inner border of the inter-maxilla, and in front it fills up the interval between the recurved tips of the inter-maxillæ. This membrane, therefore, prolongs the palate forwards to the tip of the beak. The edge of the dumb-bell-shaped bone is surrounded by the membrane, and is attached by it to the anterior free border of the palate plate of the superior maxilla."

The only author known to us who seems to have entertained a different view of the way in which the inter-crural space is filled up in the recent state, is Brühl (18), who in his plates figures the interval as partly filled up by a layer which he labels "mem." with "(car.)" in brackets.

Of the connection presently to be described between this thin cartilaginous lamella and the marginal cartilage of the upper jaw, Brühl gives not the slightest indication. In fact he does not seem to have been aware of the very existence of the marginal "labial" cartilage.

Prior to our acquaintance with this indication in Brühl, simple dissection of the space had convinced us of the cartilaginous nature of the layer which Turner has described as fibrous membrane, and this conclusion was entirely confirmed by the subsequent study of coronal sections (vide figures 1-16). But our investigation further revealed the facts, (1) that this lamina of hyaline cartilage is in direct continuity behind with the true cartilaginous nasal septum and is therefore a truly prenasal element of the axial cranial skeleton, and, (2) that it is in direct continuity in front with that "valance of solid cartilage" the superior "labial," which may, therefore, be looked upon as a forward and lateral growth and expansion of the prenasal part of the axial skeleton and as no mere labial appendage.

A study of the figures which accompany this paper will further tend to establish the conclusion that originally the inter-crural lamella and the superior "labial" cartilage were continuous, not merely mesially and in front, but also laterally, and that interruption of this continuity is due to the growth of the premaxillary as a splint grafted on both dorsal and ventral aspects of the continuous cartilaginous plate and gradually causing absorption of the latter. Figure 16 taken just at the front of the premaxilla where it is deeply grooved anteriorly for the attachment of the labial cartilage will sufficiently indicate the sense of this hypothesis.

In view of the fact that we have not as yet been able to investigate the development of this prenasal cartilaginous tract it would be rash to deny the possibility that the marginal cartilage of the upper lip *may* arise as a truly separate labial cartilage which subsequently fuses with the prenasal axial tract behind it. But, (a) the intercrural lamella of cartilage at least is certainly a greatly expanded true prenasal; (b) there is complete continuity in front between this true prenasal and the marginal cartilage of the adult upper jaw; and, (c) it is less difficult to imagine an extraordinary outgrowth in the lip of a pre-existing expanded prenasal slab of cartilage than to imagine the reappearance, or survival, in a single mammal of such an archaic feature as the superior labial cartilage for whose archetype we must "go down amongst the lower cartilaginous fishes."

Even apart from the ample development of the prenasal or rostral cartilage in some mammals, *e.g.*, the pig (*cf.* Parker and Bettany, Morphology of the Skull, 1877, figs. 77-82), the great development of the corresponding cartilaginous tract amongst some birds must be taken account of, the more especially that the avian affinities of monotremes are not to be wholly ignored.

The process of development in the bird's skull, as described by the late Prof. W. K. Parker (19) for the duck tribe, appears to us to present a close and instructive analogy to that which we suppose to have occurred in the case of the skull of Platypus.

In reference to the prepituitary portion of the chondrocranium Parker remarks, " . . . in the bird, as in cartilaginous fishes, that which forms the middle part of the foundation of the [orbitonasal] wall is carried forwards as a long 'prenasal rostrum.' This part forms most of the skeleton of the skate's large beak; in the bird it is *the temporary model on which the secondary facial skeleton is formed.*" And again (p. 10), "The morphology of the 'prenasal rostrum' is evident; it is a mere fore-growth of the intertrabecula, and in skates, sawfish, and even in some Ganoids it is often of great length."

The author then refers to his Pl. III. fig. 1, representing the ventral aspect of the skull of a nearly ripe embryo of *Cygnus nigricollis*, and to this plate we also would specially direct attention. There, in the anterior part of the beak, is seen the cartilaginous prenasal rostrum forming a considerable tract of cartilage bounded on either side by the developing premaxillæ, which are gradually encroaching upon it and causing its disappearance. If, however, this encroachment of the premaxillæ were arrested at this stage, the bones of opposite sides remaining separate, instead of fusing across the middle line to form the bony spatulate beak of the bird, we should have a condition morphologically identical with that in Platypus, due to the persistence of the inter-crural prenasal plate of cartilage. But in Platypus we must believe that the embryonic prenasal cartilaginous rostrum is a much more extensive structure than

it is in the bird, for we have not merely in the adult the persistence of the broad inter-crural plate but of that great "leafy tract" of marginal cartilage extending forwards and laterally round the free margin of the bony rostrum.

It will thus appear that the existence of a true cartilaginous homologue to the prenasal of the pig is an additional and sufficient reason for rejecting the theory that the latter is represented in Platypus by the dumb-bell-shaped bone.

We believe that the topographical and other relations of the structures under consideration will be best elucidated in detail by our commenting seriatim upon the more important features presented by series of coronal sections, of which the figures represent the most typical and significant specimens.

A coronal section of the snout of Platypus through the anterior end of Jacobson's organ is represented in fig. 1. It closely corresponds to the illustration fig. 1 of Symington's paper (20).

Here we have to note the constitution of the cartilaginous nasal skeleton as formed by the septum nasi (*s.n.*) thickened along its ventral border and in contact ventrally with the approximated ends of the alinasal cartilages (*a.n.*) which here are thickened so as to form cartilaginous capsules for the organs of Jacobson (*J*). These alinasal cartilages completely surround the nasal cavities forming the floor, lateral walls and roof of the capsules, and dorsally are seen to be continuous with the dorsal border of the septum. Ventrad of the alinasals, and closely applied to them, where they meet below the septum nasi, is the anterior expanded portion of the dumb-bell-shaped bone (*d.b.*).

In the lateral region of the section is seen the rostral crus cut across and consisting of its three bony elements—the premaxilla (*p.x.*) forming the chief constituent, supported internally and externally by the rostral processes of the nasal (*n.*) and superior maxilla (*mx.*). Wedged into a groove on the outer border of the crus between the edges of maxilla and premaxilla is the base of the superior marginal cartilage (*s.m.c.*) which extends outwards, thinning towards the free lip-margin (curled slightly in process of hardening).

For the characters of sections taken posterior to this coronal plane we refer to Symington's paper already quoted.

The subsequent figures represent the successive changes in configuration of the sections seen in passing forwards from the plane of fig. 1. Figs. 2 and 3 represent stages of transition from the foregoing type of structure. They are taken in front of the organ of Jacobson and the ventral borders of the alinasal cartilages have thus diminished in bulk. The ventral border of the septum nasi is seen to be undergoing slight lateral expansion, while the intermediate part of it immediately above is becoming constricted.

In fig. 4 (see line of section in fig. 17) the septum nasi is seen to have undergone separation into a ventral moiety (*n.s.v.*), still more expanded laterally than in the preceding sections, and a dorsal moiety (*n.s.d.*) continuous at its dorsal border with the alinasal cartilages. The ventral borders of the alinasal cartilages have become more flattened, being encroached on by the enlarging ventral part of the septum nasi.

The very anterior end by the dumb-bell-shaped bone is cut through at this plane and, being slightly notched anteriorly, it appears in two pieces. An interruption in the continuity of the alinasal cartilage dorsally is noticeable.

In fig. 5 the only important feature is the slight separation from each other of the hitherto apposed mesio-ventral borders of the alinasals, thus exposing the expanded ventral part of the septum nasi from below.

In fig. 6 the separation of the alinasals ventrally is well marked, while it is to be noted that here the ventral moiety of the septum nasi has not only become widely triangular but has descended somewhat, so as to occupy a position between, and in the same plane as, the divaricated alinasal cartilages. (See also fig. 17, *s.n.* and *a.n.*)

Fig. 7 shows how, still more anteriorly, the ventral division of the septum nasi fuses laterally with what was formerly the mesio-ventral border of the alinasal, so as to constitute a continuous floor-plate of cartilage whose composite character must not be lost sight of. It is to this cartilaginous plate that we have applied the name of "prenasal plate" (*p.n.p.*), in view of the fact that its mesial element is a forward prolongation of the ventral part of the cartilaginous nasal septum, *i.e.*, of the axial continuation of the primitive chondrocranium.

Again we would lay considerable emphasis on the great similarity, which seems to us to amount to actual morphological identity, between this condition in Platypus and that which the late Professor W. K. Parker (21) has figured in the illustration of his memoir already referred to (his Pl. III. fig. 1, and also fig. 5).

If Parker's figure of the skull of an embryo *Cygnus nigricollis*, viewed from the ventral aspect, be examined along with the view of the sagittal section in his fig. 5, and compared with our figure 17, it will be seen that, as in Platypus, so here, the nasal floor posteriorly is formed by the alinasal cartilages meeting in the mesio-ventral line, but that as they are traced anteriorly they are seen to diverge from one another while the prenasal expansion of the ventral border of the septum descends into the palate and takes up a position between them, and then extends forward as a prenasal plate between the developing premaxillæ. In Platypus, of course, the dumb-bell-shaped bone partly clothes the ventral surface of the apposed alinasals; and anteriorly the alinasals are continuous on either side with the broad prenasal plate.

Fig. 8 shows little more than fig. 7. It may be noted, however, that the continuity of the alinasal is further interrupted laterally. This change is probably to

be associated with the close approach to the region of the nostril which opens dorsally by breaking through the alinasal. At this level, too, the maxillary splint of the rostral crus has disappeared.

In fig. 10 (see line of section in fig. 17) it is to be observed that the prenasal plate has acquired an attachment to the inner border of the premaxilla, and hence it here forms a complete inter-crural plate of cartilage. It is at this plane then that the prenasal cartilage is first seen to be united by the medium of the premaxilla with the superior marginal ("labial") cartilage with which we surmise it to have been originally directly continuous laterally, as it is permanently in front. The last trace of the nasal splint of the rostral crus is seen in this section, and here in the immediate vicinity of the external nostril the horizontal septa (*h.p.*) of the nasal cavity lose their continuity between the lateral walls.

Fig. 11 passes through the hinder border of the external nostril (*ant. nar.*), and only mere traces of the horizontal septa projecting from the mesial wall of the cavity are visible. The dorsal moiety of the septum is seen to have flattened out and to have descended somewhat, but it still remains in continuity on each side with the mesio-dorsal portion of the alinasal, which here helps to form the skeleton of the nostril on the inside.

In fig. 12—a section through the middle of the apertures of the external nostrils—a somewhat odd arrangement of cartilage is seen mesially between the nostrils, due to the further descent of the remnant of the dorsal portion of the septum nasi (*n.s.d.*) and its flattening out, and to the elevation, on each side of it, into a vertical attitude, of the remains of the mesio-dorsal portion of the alinasal (*a.n.*). This rearrangement occurs rather abruptly, and at first we were somewhat puzzled by the box-like structure thus formed. A comparison of figs. 11 & 12, however, renders the structural change quite intelligible.

Further forwards, as in fig. 13, which represents a section through the anterior border of the nares, the components of the mesial cartilaginous structure just described separate from one another and increase in size, and, in fig. 14, the mesial part of the alinasal once more becomes continuous with the lateral portion, completing the cartilaginous wall of the nostril below and in front. (See also fig. 15.)

Fig. 16 (see line of section in fig. 17) shows a section taken through the very anterior tips of the premaxillary bones, exhibiting the actual continuity of the prenasal plate with the marginal cartilage of the jaw. It is to be observed that the prolongation forwards of the dorsal moiety of the septum nasi is still visible, also forming a "prenasal" cartilage (*n.s.d.*). It lies immediately dorsal to the prenasal plate, and a little more anteriorly it vanishes, while the prenasal plate becomes the "valance of solid hyaline cartilage" in front of the bony rostrum (fig. 17, *s.m.c.*).

The main conclusion from the observations recorded in this paper may be expressed as follows:—

The prenasal portion of the axis of the embryonic chondrocranium—a prolongation of the intertrabecular cartilage—does not disappear in the course of the development of the skull of Platypus, and it not only persists but attains a high degree of structural development *pari passu* with the great increase of the facial skeleton of this animal, and actually assumes considerable functional importance as part of the skeleton of the snout or muzzle.

Finally, we wish to express our thanks to Mr. J. J. Fletcher for his kindness in placing several papers at our disposal for consultation; and to Mr. Robert Grant, the able assistant in the Physiological Laboratory, for much practical assistance.

REFERENCES.

(1) HUXLEY. "Anatomy of Vertebrates," Edition 1871, p. 322.

(2) OWEN. "Comparative Anatomy of Vertebrates," 1868, III. pp. 383-4.

(3) FLOWER (and GADOW). "Osteology of the Mammalia," 3rd Edition, 1885, p. 243.

(4) MIVART. "Lessons in Elementary Anatomy," 1879, p. 247.

(5) WATERHOUSE. "Natural History of the Mammalia," 1846, I. p. 29.

(6) MECKEL. "Ornithorhynchi paradoxi descriptio anatomica," 1826, Tab. VII.

(7) PARKER, W. K. "Mammalian Descent," p. 45.

(8) RUDOLPHI. Quoted by Meckel (*loc. cit.*).

(9) MECKEL. (*Loc. cit.* p. 20.)

(10) OWEN. Article "*Monotremata*" in Todd's Encyclop. Vol. III.

(11) OWEN. "Comp. Anat. of Vertebrates," Vol. II. p. 322.

(12) FLOWER. "Osteology of Mammalia," Edition 1876, p. 219.

(13) ALBRECHT. "Sur la Fente Maxillaire et les 4 os intermaxillaires de l'Ornithorhynque," Bruxelles, 1883.

(14) TURNER. "On the dumb-bell-shaped bone in the palate of *Ornithorhynchus*," Journal of Anatomy and Physiol. Vol. XIX. p. 214-5.

(15) FLOWER (and GADOW). "Osteol. of Mammalia," 3rd Edition, 1885, p. 243.

(16) SYMINGTON. "On the nose, the organ of Jacobson and the dumb-bell-shaped bone in the *Ornithorhynchus*." Proc. Zool. Soc. 1891, Pt. IV. p. 576.

(17) TURNER. *Loc. cit.*

(18) BRUEHL. "Zootomie aller Thier-Klassen." Lief. IV. Wien, 1875.

(19) PARKER, W. K. "The morphology of the Duck and the Auk tribes." "Cunningham Memoirs," No. VI. 1890, pp. 9 and 10.

(20) SYMINGTON. (*Loc. cit.*).

(21) PARKER, W. K. "The morphology of the Duck and the Auk tribes" (*loc. cit.*).

EXPLANATION OF PLATES.

GENERAL REFERENCES THROUGHOUT FIGURES.

n.c.—Nasal cavity.
s.n.—Septum nasi.
a.n.—Alinasal.
d.b.—Dumb-bell-shaped bone.
J. —Jacobson's organ.
h.p.—Horizontal partitions of fore part of nasal cavity.
px. —Premaxilla.
n. —Nasal.
mx.—Maxilla.
s.m.c. —Superior marginal cartilage.
epith. —Epithelium covering muzzle.
n.s.d. —Dorsal moiety of septum nasi.
n.s.v. —Ventral moiety of septum nasi.
p.n.p. —Prenasal plate of cartilage.
ant.nar.—Anterior nares.
s.f. —Foramen of Stenson.
p.nar. —Posterior nares.
s.m. —Socket for horny molar tooth.

PLATES XXII.-XXIII.

Figs. 1 to 16.—Coronal sections of snout of Platypus. × 6 diameters.

Fig. 17.—Ventral aspect of facial skeleton of Platypus. Cartilage tinted blue, bone yellow. Natural size.

Note transverse dotted lines, showing planes of sections represented by figs. 4, 10 and 16.

ON THE PECULIAR ROD-LIKE TACTILE ORGANS IN THE INTEGUMENT AND MUCOUS MEMBRANE OF THE MUZZLE OF *ORNITHORHYNCHUS.*

By J. T. WILSON, M.B., PROFESSOR OF ANATOMY, UNIVERSITY OF SYDNEY, AND C. J. MARTIN, M.B., B.Sc., DEMONSTRATOR OF PHYSIOLOGY, UNIVERSITY OF SYDNEY.

(Plates XXIV.-XXVI.)

Some six months since, we were fortunate enough to have in our possession a live specimen of an adult *Ornithorhynchus.* We kept the creature in a cage containing a tank for three weeks.

The animal usually procures its food by raking away in the mud at the bottom of rivers for small larvæ, shellfish, insects, &c.* We fed ours on small snails and worms, which, together with water-weeds, were placed in its tank. At the end of three weeks we killed it in order to secure the tissues in a perfectly fresh condition for histological purposes.

During the time it had been under observation, while it was alive, we noticed among other things the markedly sensitive nature of its so-called beak. This observation, together with the fact noticed by Meckel,† of the enormous development of the fifth pair of nerves (which are absolutely very much larger than the same nerves in man, notwithstanding the fact that the animal is only about a foot and a half in length) decided us to investigate the destination of these nerves.

On removing the skin from the upper surface of the snout, the infra-orbital and nasal branches of the fifth nerves are seen emerging from their foramina and branching out in a brushlike manner towards the free margin of the snout. The infra-orbital foramina are placed in the Platypus at the lateral margins of the skeleton of the upper jaw, and their position is indicated by prominences of the bony contour of the jaw, to which the extreme hinder ends of the upper marginal cartilage are attached. (See our paper "On the Anatomy of the Muzzle of *Ornithorhynchus*" in this volume.)

* Dr. George Bennett. Trans. Zool. Soc. Vol. I. p. 229.

† Ornithorhynchi paradoxi descriptio anatomica.

As noted by Meckel * the infra-orbital nerve bundles emerging from the foramen pass forwards, some dorsad, some ventrad, of the marginal cartilage to reach the respective surfaces of the upper lip.

The abundant supply of bundles of medullated fibres is very great, and such as we have never seen in any other animal. Some idea of this extensive nerve supply may be gained by consulting fig. 12, Pl. VII., in Meckel's monograph already referred to; or our own fig. 1, Pl. XXIV., which represents a photo-micrograph of a transverse section of the extreme lateral edge of the flattened snout. In this section, which was stained by Kultschitzky's method,† the transversely cut bundles of medullated nerves are seen lying midway between the cartilage and the surface, those on the upper surface being much larger than the inferior ones. The blue-black staining of the large bundles of medullated fibres strikingly demonstrates the extraordinary wealth of nerve tissue.

In the Proceedings of the Physiological Society, June, 1884, Mr. Poulton gives a very brief account of some points in the structure of the skin covering the so-called beak of the Platypus.‡ Among other things he mentions the existence of certain rods embedded in the epidermis and arranged perpendicularly to the surface, which he describes as hair-like in structure. This author also points out that at the base of each rod two or more Pacinian bodies are applied, with their axes parallel to the surface, and he considers that these latter are operated upon by pressure applied to the slight, boss-like projections of the rods at the surface, comparing them, in fact, to the knob of the push of an electric bell.

Before we became acquainted with this brief note of Mr. Poulton's observations, we had devoted a considerable amount of attention to the investigation of these structures, and had come to conclusions which are largely identical with his as regards their general structure and probable function. In our investigations, however, a number of additional structural points have revealed themselves which represent a material extension of our knowledge of these peculiar sense organs.

Our observations have been made upon longitudinal and transverse sections, including several series, of freshly fixed tissue, treated by very various ways of staining. The most valuable for the purpose of tracing the destination of the many nerve-fibres which are supplied to each rod-like organ, we have found to be Freud's§ gold chloride, and Kultschitzky's method.||

* *Loc. cit.*

† Anat. Anzeiger, 1889, p. 223.

‡ "On the tactile terminal organs and other structures in the bill of Ornithorhynchus." Journ. Physiol. Vol. V. This paper is stated to be an abstract only, but we have been unable to discover any fuller contribution by Mr. Poulton.

§ Arch. f. Anat. u. Physiol. 1884, p. 453.

|| *Loc. cit.*

It is a matter of regret that we did not inject the living animal with a solution of methyl blue;* but we were anxious to obtain specimens of all the organs, including the brain, hardened in suitable fluids; and we were not at the time aware that we should encounter any end-organs of particular interest. We have endeavoured ever since to obtain a second live specimen to subject to this process, but hitherto without success.

For general histological investigation we used tissue treated with Flemming's fluid, or Müller's fluid, and variously stained, the best results being obtained by hæmatoxylin or hæmatoxylin and eosin, and anilin blue-black.

These peculiar organs are to be found in the skin covering both upper and lower jaws, and are not confined to the external surface only, but are freely distributed over the internal or buccal aspect, and are also found embedded in the mucous membrane covering the hard palate and that surrounding the horny molar teeth. The difference between the epithelium covering the buccal surface, and that on the external surface is very slight, and the transition from the one to the other very gradual, the thickness of the epidermis slowly diminishing as one passes inwards and backwards towards the palate.

In the case of the upper "lip" the two surfaces are distinguishable owing to the much larger amount of pigment situated in the deeper layers of the epidermis covering the external surface. Such a distinction, however, does not obtain in the lower lip.

Poulton† has drawn attention to the presence of these same organs on the transverse slightly horny ridges, on the buccal surface of the lips at either side. We further find that, in sections of the horny molar teeth, there are columns perpendicular to the surface which in parts stain slightly with nuclear stains, and which, when seen under a high power, show a series of imbricated superimposed cells arranged in a manner such as we shall show to be characteristic of the rod-like organs met with in the neighbouring mucous membrane and in the general epidermis of the snout. This appearance in the horny teeth is so striking that we cannot but regard it as due to the presence in them of similar organs which have undergone more or less cornification in common with the surrounding epidermis, so as to form a structure of sufficient hardness to subserve the dental function.

Our observations show that these organs having such an extensive distribution are most concentrated at the free margins of the upper and lower lips, especially the former.

* Ehrlich, Abhand. k. Akad. Wiss. Berlin, Feb. 25, 1885.

† *Loc. cit.*

We have also examined the mucous membrane covering the anterior portion of the snout of the Echidna and of the palate of this animal; but no such organs are present.

The organs, the general appearance of which is well shown in fig. 3, Pl. XXIV., which is a photo-micrograph of a vertical section stained with logwood and eosin, are remarkably like the roots of hairs surrounded by their follicles, but possessing no papillæ. The core is seen to be both longitudinally and transversely striated, which still further adds to the resemblance. Directed towards the base of the organ a thick leash of nerve-fibres is seen, some of which end in from two to six small Pacinian-like bodies, which are here situated in apposition with the flat base of the rod-organ.

These Pacinian-like corpuscles, together with the general nervous arrangement of the organs, will be discussed later. This rod-like organ is surrounded in its superficial half by the cells of the general epidermis, from which, however, it is sharply differentiated, as those epidermal cells which come into apposition with it are turned up so as to lie with their long axes in a direction almost vertical to the surface. They thus form a kind of follicle enclosing the rod, and are no doubt forced into their upright attitude by the upward growth of the rod (figs. 3 and 4, Pl. XXIV.; fig. 8, Pl. XXV.; and fig. 15, Pl. XXVI.).

In its deeper half the organ is surrounded by the dermal tissues, the fibrous tissue of which is arranged around it in a circular manner, so as to form a definite sheath (fig. 13, Pl. XXV.). Such a relationship with the tissues of the cutis is probably occasioned by the epithelial downgrowth which forms the rod causing a depression in the summit of a dermal papilla.

The epithelial elements composing the shaft of the organ are arranged in three concentric layers, as may be seen in fig. 15, Pl. XXVI., which is a semi-diagrammatic representation of a vertical axial section, or in the photo-micrograph of a transverse section of the organ, in its passage through the epidermis (fig. 6, Pl. XXIV.). In this latter the three rings of nuclei belong to the three layers.

The innermost layer, whose elements constitute the core, is made up of a number of superimposed imbricated epithelial laminæ, each of which is in the shape of a hollow truncated cone. These elements are compound and made up of three or more nucleated cells, but we have been unable to discover any differentiation between the component cell-bodies, and have come to the conclusion as to their compound nature on account of their possessing three or four nuclei, which nuclei form the most centrally disposed group, seen in the photo-micrograph of a transverse section, already referred to.

An idea of the shape and relations of these elements may best be obtained by referring to the diagram, fig. 16, Pl. XXVI., which represents the side view of these truncated cones. In fig. 15 is shown a semi-diagrammatic drawing representing the various elements of the core unnaturally separated from each other: the central portion shows the elements of the core in optical section. These diagrams have been largely constructed from teased specimens of sections of the rods. Fig. 17, Pl. XXVI., shows two of the elements of the core and one cell from the neighbouring layer, drawn to nature from such a teased specimen. The section has gone vertically through the core, so as to divide the cones into two nearly equal halves, which halves are seen as it were from the inside. Each half possesses a nucleus.

In the natural condition these conical elements are placed one upon another as closely as possible, so that in a longitudinal section of the entire organ the periphery of the core appears obliquely striated at about an angle of 45° to the axis of the organ (fig. 5, Pl. XXIV., or fig. 22, Pl. XXVI.).

The apical end of the truncated cone is formed by a sharp inflection of the upper edges of the epithelial lamina, which meet or nearly meet in the axis of the cone. In section the profiles of these inflected edges present a clubbed appearance. (This description and the illustrative diagrams might suggest that only a minute axial canal is left in the centre of the core; but such a conclusion would certainly be erroneous, since, as we shall by and by see, a whole leash of fibrils occupies this area. We believe that at their central ends the epithelial cell elements of the conical laminæ are partially detached from one another to admit the passage of the fibrils referred to.)

The intermediate layer consists of narrow imbricated nucleated cells arranged not unlike the tiles of a roof, at a more oblique angle to the axis than those of the laminæ forming the core, and completely encircling this latter. These cells form the second nucleated circle seen in fig. 6, Pl. XXIV. External to these is a layer of polyhedral nucleated cells arranged in a circular manner around the last-named layer, and constituting the outermost layer of the shaft. The longer axes of these polyhedral cells have a nearly horizontal direction.

Surrounding the so-constituted shaft of the rod-organ one finds in the superficial half the general epidermis, the neighbouring cells of which are pushed from their usually horizontal direction into an oblique or nearly vertical position, presumably by the upward growth of the organ. In the deeper half it is surrounded by the dermis, which forms for it a compact fibrous sheath. The external relations of the organ will in its different parts be at once seen on looking at figs. 3, 4, and 6, Pl. XXIV., and fig. 13, Pl. XXV.

The nerve apparatus with which each rod-like organ is equipped consists of the thick leash of medullated nerve-fibres already referred to, together with the various terminations of these fibres, which end in three distinct ways. Two of these different kinds of nerve-endings are associated with the presence of special end-organs, while fibres of the third class of ending terminate in free fibrils in the manner subsequently to be described.

The first method of termination is that described by Poulton,* viz., in four or five small Pacinian-like bodies. We may quote from this author as follows:—"Inferiorly these rods terminated in a convex surface, against which a group of small Pacinian bodies was always collected. Horizontal sections showed that this association was invariable, and that the groups usually contained four, five, or six Pacinian bodies. The Pacinian bodies were quite similar to those in the tongue of *Ornithorhynchus*.† They are arranged with their sides parallel to the surface from which the pressure is communicated."

In respect of the Pacinian-like bodies, we have very little to add to the descriptions of this author in the journals above-mentioned. We have, however, noticed that very frequently, in addition to the four or five small Pacinian-like bodies situated in the position mentioned by Poulton, one or more bodies, similar as regards structure, but of a size two or three times as great, are found lying in the dermis, a short distance from the base of the organ (figs. 7, 8, and 9, Pl. XXV.). These Pacinian-like bodies are substantially identical with those described by Corti‡ as occurring in the tongue of the elephant, and figured by Krause in his paper§ on the nerve-endings in terminal corpuscles, under the name of "Endkapseln."

The second mode of nerve-ending is one which has not been noted by Mr. Poulton. Some of the nerve fibres proceeding towards the base of the rod-organ, and passing in close proximity to the Pacinian-like bodies, enter the base of the rod to end in a number of specialised organs which do not precisely correspond in character to any other form of nerve end-organ known to us. These bodies, which we have accustomed ourselves to call "lenticular bodies," are oval in shape and about 13μ in their longest diameter, and appear to consist essentially of two clear vesicular cell-like structures, shaped somewhat like plano-convex lenses. Between the approximated plane surfaces of these is placed an intermediate layer, forming a disk or meniscus, which stains deeply with gold chloride, while the other elements remain for the most part untinged. This disk is in direct continuity with the axis-cylinder

* *Loc. cit.*

† Quart. Jour. Micro. Sci. July, 1883.

‡ Zeitschrift für wissenschaftliche Zoologie, 1854, Bd.V. S. 89

§ Arch. für mikroskopische Anat. Bd. XIX. S. 61, u. fig. 8. Taf. III.

of a nerve-fibre, and may be regarded as the flattened and expanded termination of the latter. It would thus seem to correspond in some of its morphological characters and in its probable significance, to the menisci or tactile disks described and figured by Ranvier* in the epidermis of the pig's snout. These lens-like bodies are small, scarcely larger than the surrounding epidermal cells of the base of the rod, and we have so far been unable to detect nuclei in the demilunes in spite of the clearness of their substance. A nerve-fibre, on approaching one of these end-organs, is seen to lose its medullated sheath shortly before joining the body, whilst the primitive sheath is continued so as to form a delicate capsule for the organ. The structure of these end-organs may be seen by referring to fig. 10, Pl. XXV., and figs. 18, 19, and 20, Plate XXVI. The last figure is semi-diagrammatic.

The principle of this arrangement is similar to that which obtains in the constitution of a Grandry's corpuscle. But in the first place the lenticular bodies here described are intra-epithelial, and not sub-epithelial like Grandry's. Secondly, the average size of the latter corpuscles, as given by Krause,† is 67μ, which is five times the size of our "lenticular bodies." Lastly, a well-marked vesicular nucleus and nucleolus are always to be seen in the component cells of the corpuscles of Grandry.

The third species of sensory nerve-termination with which the rod-organs are provided consists of a rich supply of fine terminal fibrils traversing the shaft of the rod from base to surface. These fibrils were observed and described by Mr. Poulton, but he failed to recognise their nervous character and connections.

Those medullated nerve-fibres which do not end either in the Pacinian-like bodies or in the "lenticular bodies," enter the base of the rod in two fairly distinct series, a central and a peripheral. The fibres of the central group are pretty closely associated with the fibres for the lenticular bodies, and enter the rod by piercing its flat basal surface. Here they find their way for a short distance between the epithelial cells, being directed towards the axis of the rod. They then suddenly lose their white sheaths and the naked axis-cylinders, which are here frequently branched, and are continued peripherally along the axis of the shaft, forming a bundle of delicate parallel fibrils (figs. 11 and 21, Plates XXV. and XXVI.).

In transverse section this bundle of fibrils is seen to occupy a circular area in the centre of the core, corresponding to the axial region of the epithelial conical laminæ already described (fig. 13, Pl. XXV.). In their course the fibrils of this central or axial bundle must traverse the inner portion of the core as represented by

* Compt. Rend. 1877. Tome LXXXV.

† Krause, *loc. cit.* S. 87.

the lines *af* in fig. 15. In some transverse sections of the rod they appear to nearly fill the centre of the core (fig. 13, Pl. xxv.), while in others they are arranged as a circle around the centre (fig. 6, Pl. xxiv.).

The peripheral series of nerve-fibrils form a complete circle running vertically from near the base to the surface, and situated between the epithelial conical laminæ which constitute what we have designated the core (*c*, in fig. 15), and the layer of imbricated cells outside this (*m*, fig. 15). They are shown as a circle of dots in this position in the transverse sections (fig. 6, Pl. xxiv., and fig. 13, Plate xxv.).

The medullated nerves from which these fibrils spring enter the sides of the organ a short distance above the base (figs. 19 and 21, Pl. xxvi.).

After entering they speedily lose their medullated sheaths and give rise to a number of small fibrils, which find their way amongst the epithelial cells forming the basal portion of the organ [and so far not arranged into any definite circular series, such as was described above in the more superficial part of the organ (fig. 21, Pl. xxvi.)], until they arrive between the core and the layer of imbricated cells. They then run vertically upwards in a parallel course to the surface.

The fibrils of both groups present a very characteristic appearance; they are finely and closely varicose throughout, and the varicosities are situated all at the same levels in each of the parallel fibres of the groups. These varicosities occur in the intervals between the superimposed epithelial elements, as is semi-diagrammatically shown in fig. 15, Pl. xxvi. They can be seen both in the stained and unstained specimen. In fig. 12, Pl. xxv., and fig. 22, Pl. xxvi., there is represented a specimen stained with hæmatoxylin, by which the fibrils are left unstained, showing a broken rod-like organ, from the fractured end of which the varicose fibrils may be seen projecting, like the antennæ of some insect. The fibrils, however, are best seen in fig. 21, Pl. xxvi., which is a drawing from a section stained by gold chloride by Freud's method, by which these structures are very beautifully brought out as deep purple or violet lines, whereas the surrounding structures are only faintly stained.

The nerve fibrils can be traced almost, if not quite, up to the convex free surface of the rod; but towards the surface they are only faintly discernible, as they, along with the epithelial elements of the rod, participate in the corneous change which the superficial layers of the epidermis undergo. This corneous change, however, is never so complete as to obliterate the contours of the cell elements and nuclei either in the structure of the rods or in the surrounding epidermis.

In conclusion, we have pleasure in expressing our best thanks to Dr. T. H. Barker, of Wellington, N.S.W., for his kindness in procuring and forwarding the live

specimen of *Ornithorhynchus*, and to Prof. Anderson Stuart for his courtesy in placing at our disposal well-hardened specimens of the snout of Echidna for comparative study.

In the production of the illustrations which accompany this paper we have to express our large indebtedness to Mr. Robert Grant, the able assistant in the Physiological Laboratory, with whose photo-micrographic camera, and with whose valuable assistance, some of our best photo-micrographs were obtained. Much other incidental aid in the preparation of the illustrations has been rendered us by the same enthusiastic helper.

EXPLANATION OF PLATES.

PLATE XXIV.

Fig. 1.—Photo-micrograph of vertical section of lateral margin of snout ("upper lip") of Platypus. Kultschitzky's stain. Zeiss' 70 mm. objective without ocular. × 12 diameters. *Cf.* key drawing, fig. 14, Pl. XXVI.

Fig. 2.—Photo-micrograph of vertical section of skin of snout of Platypus. Picrocarmine stain. Beck's $\frac{1}{2}$-inch objective without ocular. × 70 diameters. Shows general view of epidermis in section, including vertical section of two rod-like organs.

Fig. 3.—Photo-micrograph of vertical section of rod-like organ and neighbouring epidermis. Hæmatoxylin stain. Zeiss' objective A, compens. ocular No. 6. × 135 diameters. Shows general view of structure of rod-organ, with thick leash of nerve-fibres passing to it in dermal tissues, and two Pacinian-like bodies at its flattened base.

Fig. 4.—Photo-micrograph of superficial half of the rod-like organ shown in fig. 3. Zeiss' objective D, compens. ocular No. 6. × 625 diameters. The shaft of the rod is best defined in the lower part of the figure, where the different layers are easily distinguishable (see fig. 15 for semi-diagrammatic representation of the various elements). The comparatively wide and striated core of the shaft is constituted by the structures marked *c.* in fig. 15, and corresponds to the whole space in fig. 15 between the two lines marked *p.f.* This core is seen to be bounded by a well-marked layer with deeply stained nuclei, constituted by the imbricated cell-elements marked *m.* in fig. 15; while immediately external is the layer of large polyhedral cells marked *p.* in fig. 15. Outside this layer in the upper part of the photo is the layer of slightly modified cells of the general epidermis, marked *e.* in fig. 15, and in the lower part of the photo also is a somewhat irregular layer of slightly modified epidermal cells, outside which are found the dermal tissues, which completely surround the lower half of each rod.

Fig. 5.—Photo-micrograph of vertical section of middle part of rod-like organ, fixed in Flemming's fluid and unstained. Beck's objective $\frac{1}{6}$ inch without ocular. × 200 diameters. To illustrate structure of shaft of rod-like organ.

Fig. 6.—Photo-micrograph of horizontal transverse section of rod-like organ in its superficial half. Hæmatoxylin stain. Zeiss' 4 mm. apochromatic objective, projection ocular No. 2. (Achromatic condenser). × 435 diameters. The innermost four to five nuclei are those of the conical epithelial laminæ referred to in the text. In the area surrounded by these nuclei is to be seen a circular arrangement of white dots, which are the transverse sections of the axial group of nerve-fibrils, while external to the nuclei is a wider circlet of white dots, which are the peripheral series of nerve-fibrils. Immediately surrounding the latter is a circle of dark transversely elongated nuclei, which are those of the imbricated cell-elements marked *m.* in fig. 15. Outside this circle again is the thicker layer and polyhedral cells, enclosed in turn by the modified cells of the general epidermis, which are, however, at this level slightly interrupted by the very tips of the dermal papillary upgrowths surrounding the rod and here just cut across.

PLATE XXV.

Fig. 7.—Photo-micrograph of horizontal transverse section through the layer of Pacinian-like bodies immediately subjacent to the flattened base of a rod-organ. Anilin blue-black stain. Beck's $\frac{1}{6}$ inch objective, no ocular. × 200 diameters. Between and around the Pacinian-like bodies may be seen sections of medullated nerve-fibres on their way to enter the base of the rod.

Fig. 8.—Photo-micrograph of vertical section, lower half of rod-like organ shown in fig. 3. Beck's $\frac{1}{6}$ inch objective, without ocular. × 200 diameters. To show the thick bundle of medullated nerve fibres ascending towards the base of the rod, two Pacinian-like bodies beneath the flat base of the rod, and a number of "lenticular" nerve end-organs embedded among the epidermal cells forming the base of the rod. In the shaft of the organ the longitudinal striation due to the presence of the axial and peripheral groups of nerve-fibrils is visible.

Fig. 9.—Photo-micrograph of vertical section of base of another rod-organ. Hæmatoxylin stain. Beck's objective $\frac{1}{6}$ inch, without ocular. × 200 diameters. Shows group of "lenticular bodies" in base of rod and a Pacinian-like body in the dermis at some distance below the rod, and of larger size than those placed immediately under the base.

Fig. 10.—Photo-micrograph of vertical section of base of another rod-organ. Freud's gold chloride stain. Zeiss' 3 mm. apoch. hom. imm. objective. Projection ocular No. 2. (Achromatic condenser). × 580 diameters. Shows two "lenticular bodies" in base, with horizontal dark stained line crossing each, due to the gold impregnation of the nerve disk or meniscus between the lens-shaped cell elements. Also nerve-fibres passing into base of rod to give off terminal fibrils.

Fig. 11.—Photo-micrograph of vertical section, basal portion of rod-like organ. Freud's gold-chloride stain. Zeiss' 4 mm. apochrom. objective. Projection ocular No. 2. (Achromatic condenser). × 435 diameters. Shows more especially the medullated nerve-fibres entering the base of the rod and there losing their white sheaths, the axis cylinders breaking up into the terminal nerve-fibrils, which course peripherally through the shaft. Observe that the fibres which give off the peripheral group of nerve-fibrils enter the lateral aspect of the rod slightly above the base.

Fig. 12.—Photo-micrograph of vertical section of rod-organ, *broken about its middle.* Hæmatoxylin stain. Zeiss' D objective, compens. ocular No. 6. × 625 diameters. Shows bundle of varicose nerve-fibrils belonging to axial group projecting, antennæ-like, from broken end of rod-like organ into empty space formerly occupied by peripheral end of rod. Observe that the fractured end of the core of the rod exhibits the profile-contour of one of the truncated conical epithelial elements figured semi-diagrammatically in fig. 16 (*c*).

Fig. 13.—Photo-micrograph of horizontal transverse section of rod-organ in its deeper half. Anilin blue black stain. Beck's $\frac{1}{6}$ inch objective, without ocular. × 200 diameters. The rod, here in its deeper half, is completely surrounded by the dermal tissues. Note the central axial group surrounded, at some distance, by the circlet of the peripheral set of nerve-fibrils, all appearing as white dots.

PLATE XXVI.

Fig. 14.—Outline drawing to serve as key to photo-micrograph, fig. 1, Plate XXIV.

Fig. 15.—Semi-diagrammatic representation of the constituent elements of the shaft of a rod-like organ. *e.*, cells of general epidermis slightly modified and forming a kind of follicle; *p.*, outermost layer of shaft formed of large polyhedral cells; *m.*, layer of imbricated flattened cells with deeply-staining nuclei, which are transversely elongated, see fig. 6, Plate XXIV.; *c.*, hollow truncated conical epithelial laminæ formed by fusion of nucleated epithelial cells. These peculiar elements are shown in optical section, as from the inside, as well as in sectional profile. *p.f.* represents one of the peripheral circles of terminal nerve-fibrils; *a.f.* represents one of the axial systems or groups of terminal nerve-fibrils. Observe that the varicosities regularly alternate with the epithelial laminæ.

Fig. 16.—Diagrammatic representation of the superimposed truncated conical epithelial laminæ which make up the core of the rod. *c.*, conical laminæ, nucleated; *a.f.*, axial group of nerve-fibrils.

Fig. 17.—Drawing of teased elements from core of rod-like organ. Stained hæmatoxylin and eosin. × 300 diameters. *c.*, conical epithelial lamina; *n.*, one of its nuclei; *m*, one cell of the imbricated layer (*m.* in figs. 6 and 15).

Fig. 18.—Transverse section through extreme base of rod-like organ. Anilin blue-black stain. × 250 diameters. *l.*, "lenticular bodies"; *P.*, tip of a Pacinian-like body; *w.*, medullated nerve-fibres; *d.*, ensheathing dermal tissue.

Fig. 19.—Vertical section of basal part of rod-like organ and its nerve apparatus. Freud's gold chloride stain. × 820 diameters. Shows medullated nerve-fibres in lower part of drawing, ascending tortuously towards the base of the rod. Two Pacinian-like bodies are seen beneath the flat rod base and two "lenticular bodies," one with a nerve-fibre joining it is seen amid the epithelial cells of the base of the rod. In addition two medullated nerve-fibres are seen to enter the side of the base and, losing their white sheaths, they give origin to terminal fibrils of the peripheral circlet.

Fig. 20.—Semi-diagrammatic representation of a "lenticular" nerve end-organ, with nerve-fibre joining it. × 1300 diameters. *v.*, vesicular cell-like structures; *sh.*, sheath, continuous with neurilemma; *nu.*, flattened nuclei in sheath; *me.*, disk or meniscus continuous with axis-cylinder of nerve-fibre; *ax.*, axis-cylinder of nerve-fibre; *w.*, medullary sheath of nerve-fibre.

Fig. 21.—Vertical section rod-like organ. Freud's gold chloride stain. Shows nerve-apparatus, including Pacinian-like and "lenticular" bodies, and axial and peripheral systems of terminal fibrils. *y.*, nerve-fibres extending upwards, the tissues of dermis in cleft between rod and general epidermis.

Fig. 22.—Drawing of same section as that represented in fig. 12, Pl. XXV. Hæmatoxylin stain. Zeiss' apochrom. objective 4 mm., compens. ocular No. 6. × 400 diameters. The fibrils are as distinct in the specimen as in this drawing, but they are not black but only highly refracting.

ON *PARMACOCHLEA FISCHERI*, SMITH.

By C. Hedley, F.L.S.

(Plate xxvii.)

For an opportunity of dissecting an example of *Parmacochlea fischeri*, Smith, I am indebted to the Committee of Management of the Macleay Museum, who kindly sacrificed a specimen of their collection for the purpose. I have further to gratefully acknowledge the permission granted to me by the Trustees of the Australian Museum to devote the necessary time to the study of this mollusc and to communicate the result to the Macleay Memorial Volume.

The species was first noticed in "An Account of the Land and Freshwater Mollusca collected during the Voyage of the 'Challenger' from December, 1872, to May, 1876," by Edgar A. Smith, P.Z.S. 1884, p. 273, Pl. xxiii. figs. 15-15c. A new genus was here created for the reception of a mollusc of which one half-grown example was procured at Cape York, Queensland, by the "Challenger" collectors. Since the publication of these figures and description of the external features and shell scarcely anything has been added to our stock of information regarding this animal. It has, however, been frequently collected by Australian naturalists and appears to be a characteristic and fairly common form along the coast of tropical Queensland, northward of S. latitude 20°.

The Macleay Museum representatives were collected at Cairns by Mr. Froggatt. Mr. Brazier chronicles it under the name of *Vitrina* sp. (P.L.S.N.S.W. (1), Vol. I. p. 129, species 64), from No. III. Island, Barnard Group, and describes the creature's habits as arboreal. Mr. Beddome also took this species at Cardwell; and it was observed by the writer at the Bloomfield River, near Cooktown.

At the close of the briefest summary of the species (Manual of Conchology, Ser. 2, Vol. I. p. 167) Tryon remarks, "*Vitrina australis*, Reeve, is suspiciously like this species." On comparing *V. australis*, as portrayed in the "Conchologica Iconica," Vol. XIII., Article "*Vitrina*," Pl. x. fig. 70, with the figures 15b and 15c of Pl. xxiii. P.Z.S. 1884, representing the shell of *P. fischeri*, no suspicious likeness, but a very tangible distinction, presents itself to me.

V. australis is not at present known to inhabit Australia on any other authority than that of Cuming, whose inaccuracy in such matters was proverbial.

The spirit specimen I have before me measures 27 mm. in total length; the muzzle projecting about 4 mm. in front of the mantle neck-lappet, and the tail 12 mm. behind the visceral hump. From the sole of the foot to the top of the visceral hump is 10 mm., and from sole to keel the tail is $4\frac{1}{2}$ mm. high. From the pulmonary orifice to the muzzle measures 10 mm.

The outline of my example somewhat resembles that of the spirit specimens of *Cystopelta petterdi*, Tate, (P.L.S.N.S.W. (2) V. Pl. I. fig. 1), and of *Parmella etheridgei*, Brazier, (Rec. Aust. Mus. I. Pl. XI. fig. 1), consisting of a narrow straight foot surmounted by an oblong visceral hump. Probably from having been plunged into stronger alcohol, my example is more shrunk and the visceral mass rises more abruptly than in the "Challenger" specimen. Both probably bear the same relation to the living snails as the above-quoted figure of *C. petterdi* does to the figure subsequently published (P.L.S.N.S.W. (2) VI. Pl. III. fig. 5). To further illustrate its probable appearance in life, and for comparison of the mantle lobes, I add a drawing of its ally, *Helicarion robustus*, Gould.*

In death, the mantle, retracted from a heart-shaped space 7 mm. wide, exposes a portion of the shell; but in life it probably conceals the whole. The shell is that shade of sherry yellow common to other of the *Helicarioninæ*, and, though thin, is sufficiently stiff to form a flat roof to the visceral hump. The mantle is finely wrinkled and papillate. Though its lobes have grown together much more than in *Helicarion*, they have not attained the extreme development of *Cystopelta*, where the shell has entirely disappeared and the lobes are fused together into one seamless whole. Neither has *P. fischeri* reached the stage of *Parmella etheridgei*, where the various lobes have become atrophied, for diminutive right and left dorsal lobes are still preserved (Pl. XXVII. figs. 1, 2 a and b). The sides and sole of the foot are a pale ochreous-yellow, facial area blackish and the mantle a purplish-brown. The tail, of the same height throughout and possessing the usual pedal line and diagonal grooves, is sharply keeled and terminates in a large mucous pore cleft to the sole, but not overhung by a horn.

Shell, $16\frac{1}{2}$ mm. long, 9 mm. wide and 5 mm. deep, when freshly extracted; rudimentary, thin, transparent, waved and striated concentrically and crossed by faint spiral grooves; somewhat like a finger-nail in shape and texture. Whorls two and a-half, rapidly increasing, the mode of growth passing from spiral to straight; the last whorl diverging, like a *Dolabella* shell, from its predecessor with which a wrinkled,

* This sketch was made Sept., 1888, from a specimen found at Little Nerang Creek, South Queensland, which is thus described in my note-book. "*Helicarion*, sp.—Total length, 46 mm. Colour generally light yellow; mucous gland brilliant pink, neighbourhood of gland and sole of foot a fainter pink; tubercles of keel orange; grooves diagonally across the back an intense black; mantle flesh-coloured with irregular black spots. Keel terminating posteriorly in a horn-shaped projection above the gland. When extended shows a flat white saddle-like space behind the shell. Tentacles rather long, finely tuberculated. The space between the tentacles and the mantle covered with narrow longitudinal tubercles. Mantle coarsely papillate, the two lobes completely covering the shell when the animal is undisturbed. Sole of foot divided longitudinally by a median area."

white, shelly, supplementary plate connects it; fringed around the circumference by a short, thin, membranous, epidermal margin. The suture of the last whorl is margined and overlies the anterior edge of the supplementary plate, being contorted on reaching it. Nuclear shell submarginal; viewed from beneath it resembles a slipper having the apex for a toe. The hard calcareous wall of the apical pouch is continued along beneath the suture of the last whorl, dividing the interior of the shell into two chambers, the smaller of which is roofed by the supplementary plate. Deep within the nuclear shell appears a twisted columella, whose position is marked on the exterior wall by a groove. The shell appears to have pursued its erratic course from the earliest infancy; when freshly hatched the appearance of the shell might elucidate the history of the development of the species.

Jaw rather straight, flat and smooth, obtusely keeled in the centre, keel terminating below in a rounded median beak, above emarginate, ends rather square.

The radula is in shape a parallelogram, measuring $4\frac{1}{2}$ by $1\frac{1}{2}$mm. and consisting of 152 rows of 54 : 20 : 1 : 20 : 54; the laterals squarely cross the membrane in a waved line; from them the marginals curve outwardly and anteriorly. Rachidian: basal plate a third longer than broad, anterior and posterior margins straight, lateral ones bent inwards, causing the general outline to resemble that of an hour-glass; reflection the breadth of the base, divided a little posterior to the basal constriction into three cusps, the central and largest being lanceolate, surpassing by half its length the basal margin, the outer cusps a quarter the length of the parent, dentate and furnished with considerable cutting points. Laterals rather larger than the rachidian; basal plate sinuate, a proximal projection fitting into the constriction of the rachidian's basal plate, the posterior proximal angle suppressed, the alate or distal one moderately developed; reflection with the inner cusp suppressed, the site marked by a slight projection, the main and distal accessory cusps well developed. About four irregular teeth are transitional, to which succeed the marginals, numerous, inclined, slender, sinuate, cusp bicapitate, base distal, roughly triangular, its posterior angle sometimes appearing like a third cusp to its second neighbour. A considerable portion of the viscera is lodged in a cavity excavated in the substance of the foot; in this respect *Parmacochlea* advances nearer to the condition of *Limax* than do *Cystopelta* or *Parmella.* The genital system resembles on the whole that of the *Helicarion* figured by Col. Godwin-Austen, "Land and Freshwater Mollusca of India," Pl. XLI. figs. 8, 8a, but varies from it much in detail. In addition to a "kalk sac" similar to *k* of the figure quoted, a second cæcum exists close to the attachment of the retractor muscle, distinguished as *x* in my figure. The apparatus is further remarkable for the excessive multiplication of the convolutions of the vas deferens, which form an intricate mass spread along the base of the duct of the spermatheca. The latter is comparatively short and wide, supporting a large globose head.

SUMMARY.—The chief peculiarities of the mollusc under discussion are: the uncoiling of the whorls and the insertion of the intersutural supplementary plate of the shell, the partial atrophy of the mantle lobes, the numerous convolutions of the vas deferens and the sac developed on the penis near the origin of its retractor muscle. The resemblance, both external and internal, of *Parmacochlea* to *Helicarion* calls for its classification beside that genus in the subfamily *Helicarioninæ*, while the differences between them clearly entitle it to generic rank. The abnormal shell induces me to suppose a descent and divergence from some form very similar to *Helicarion robustus*, Gould.

EXPLANATION OF PLATE.

PLATE XXVII.

Fig. 1.—Animal of *Parmacochlea fischeri*, as contracted by alcohol, magnified, seen from the left side, showing *b.* left dorsal mantle-lobe. Magnified.

Fig. 2.—The same from the right side, showing *a.* right dorsal mantle lobe. Magnified.

Fig. 3.—Genital system of the same. Magnified.

Fig. 4.—Detail sketch of penis, further enlarged, showing *p.* penis-sheath, *r.m.* its retractor-muscle, *x.* cæcum, *k.* flagellum, and *v.d.* vas deferens.

Fig. 5.—Shell of the same, as seen from above after stripping off the mantle. Magnified.

Fig. 6.—The same, removed and seen from within. Magnified.

Fig. 7.—Jaw of the same. Magnified.

Figs. 8, 9 and 10.—Teeth from the centre and margin of the radula of the same. Much magnified.

Fig. 11.—Animal of *Helicarion robustus*, Gould, for comparison with the preceding, from life, viewed from the left side and magnified.

ON THE GEOGRAPHIC RELATIONS OF THE FLORAS OF NORFOLK AND LORD HOWE ISLANDS.

By Professor Ralph Tate, F.L.S., F.G.S., &c.

CONTENTS.

I.—Introduction.

Mr. Bentham in his "Flora Australiensis" includes the names of the plant-species of Lord Howe Island under the provincial heading of New South Wales; and so also does Baron Sir F. von Mueller in his "Census of Australian Plants," adding, however, those of Norfolk Island. I do not know if the attachment of these insular floras to New South Wales be intended as an expression of their geographic relationship, or whether it be from the circumstance that the two islands are under the governmental jurisdiction of that colony. Political dependency cannot influence or determine botanical correlation; and even if the floras of these islands have a decided continental facies, it would be desirable, on account of geographic isolation, to keep them distinct. But the main contention is, however—are the floras Australian; and, if not, to what region of the Australasian Province do they belong?

This inquiry has been largely promoted by the knowledge that the affinity of the land faunas, particularly in the classes of birds and gastropods, is rather with Polynesia and New Zealand than with Australia.

Norfolk Island is situated about 600 miles due east from Port Jackson, and is about the same distance south from New Caledonia and north from New Zealand; so that, from a geographic point of view, its terrestrial life might be expected to partake equally of the characteristics of the three regions—New Caledonia, New Zealand and New South Wales. Lord Howe Island is midway, or thereabouts, between Port Jackson and Norfolk Island; and because of its nearness to the continent the alliances of its fauna and flora might be expected to be largely if not wholly Australian.

II.—GEOGRAPHIC RELATIONS OF THE TERRESTRIAL FAUNAS.

Mr. Wallace* considers Norfolk Island, as well as Lord Howe Island, to belong to the New Zealand region, chiefly on account of the presence of certain New Zealand genera of birds, which are incapable of long flights.

Mr. A. Sidney Olliff† writes that—"Among the Coleoptera of Norfolk Island, the most conspicuous genera—*Lamprima*, *Chiroplatys*, *Melobasis* and *Toxeutes*—are all characteristically Australian; and *Metisopus*, the only endemic genus, is certainly allied to Australian groups. In fact, the only typical New Zealand form is *Xyloteles*, which is represented by two closely allied species. The occurrence of *Enicodes*, a remarkable New Caledonian form, is particularly suggestive."

The evidence afforded by the land mollusca points to a New Zealand and Polynesian affinity. The land-snails of Lord Howe Island are all endemic, and "among the inoperculate group," writes Mr. Hedley,‡ "the auriculoid *Placostylus* claims affinity with New Zealand and New Caledonia and utterly repudiates kinship with Australian life." Among the operculate group, *Omphalotropis*, which is chiefly Polynesian, is represented by one species each in Australia, Lord Howe Island, Norfolk Island and New Zealand; *Realia*, which has one species in Lord Howe Island, is a small genus belonging to New Zealand (4 spp.) and Marquesas Island (3 spp.).

* "Geographical Distribution of Animals," Vol. I. p. 453.

† "P.L.S.N.S.W." Vol. II. 1887, p. 1002.

‡ "Records of the Australian Museum, N.S.W." Vol. I. No. 7, 1891.

III.—GENERA OF LORD HOWE AND NORFOLK ISLANDS IN RESPECT OF THEIR GEOGRAPHICAL DISTRIBUTION.

The following table summarises the affinities of the genera in their geographical relationship; the details of which are given in the appended List of Genera.

Regional Distribution.	Howe.	Norfolk.	Common to both.
I. Extra-Australian—			
Endemic	4	2	—
Extra-limital	3	5	—
II. Australasian	29	17	14
III. Australian	4	4	1
IV. Cosmopolitan	69	31	25
V. Oriental	45	17	16
Total	154	76	56

IV.—GENERA OF PLANTS IN NORFOLK ISLAND.

The tabular arrangement of the extra-Australian genera presents at a glance their geographic distribution, though it does not indicate their genetic relationships, which may very much modify any deductions drawn only from the former.

The peculiar genus *Ungeria* has some affinities with *Helicteres*, occurring in all warm regions, but is more nearly related to *Reevesia* of the Oriental region.

The other endemic genus, *Streblorrhiza*, is closely related to *Carmichaelia*, which contains one species each in Lord Howe Island and New Zealand.

Procris is an Oriental genus extending to Papua and some of the Pacific isles, but is not yet known in Australia.

Melicytus is peculiar to New Zealand, with the exception of the endemic species in Norfolk Island.

Meryta is a larger genus than *Melicytus* and is essentially New Zealandian, but has two or three outlying species in Norfolk Island and the South Seas.

Phormium is represented by two species inhabiting New Zealand, one of which extends to Norfolk Island.

Rhopalostylis, H. Wendland and Drude. I have adopted the dismemberment of *Kentia*, as approved by Bentham and Hooker in their "Genera Plantarum," if for no other reason than that it expresses tersely the inter-relations of the Australasian species of the composite genus *Kentia*. Thus *Rhopalostylis* is restricted to *Kentia Baueri* in Norfolk Island and *K. sapida* in New Zealand.

Of the seventeen genera so characteristic of the Austro-Polynesian region, four only are absent from New Zealand, viz., *Baloghia*, *Pseudomorus*, *Geitonoplesium* and *Araucaria;* the first predominates in New Caledonia, but two species of it have extended to Continental Australia, one of them being widely distributed in Polynesia; *Geitonoplesium* is a monotypic genus differing by inflorescence from *Eustrephus*, a monotypic Australian genus, and from *Luzuriaga*, a small genus belonging to the Andean and New Zealand regions; *Araucaria* is usually regarded as an Andean genus spreading westward as far as Eastern Australia; *Drimys* is of nearly equal value with *Araucaria;* and *Coprosma* is pre-eminently a New Zealand genus. On the other hand *Metrosideros*, *Myoporum*, *Microtis* and *Dianella* indicate closer affinities with Australia than with any other region of the Australasian Province.

Of the four Australian genera common to Norfolk Island, *Lagunaria* is monotypic—scarcely perhaps sufficiently distinct from *Hibiscus* (according to Bentham), a very large genus widely dispersed throughout the tropics and extending to warm temperate regions—and may be equally claimed by Norfolk Island or Australia; *Bosistoa*, comprising one species peculiar to Australia and one restricted to Norfolk Island, perhaps because of its alliance with *Melicope* may be regarded as of Polynesian origin; *Boronia* is, with the exception of the peculiar species in Norfolk Island, restricted to Australia; *Eriostemon* (in the extended sense used by Baron von Mueller) is a large genus with one species each in New Caledonia and New Zealand and two in Norfolk Island—a distribution suggestive of its inclusion in the list of Australasian genera.

In the discussion of the generic affinities of the flora of Norfolk Island, we may leave out of consideration those genera of cosmopolitan distribution and those of Oriental origin. In regard to those genera of Australasian origin, the major number of them seem to be nearly equally balanced between Australia and New Zealand, but in the extra-Australian genera *Streblorrhiza*, *Melicytus*, *Meryta*, *Phormium* and *Rhopalostylis* turn the scale in favour of New Zealand as against *Boronia* and *Eriostemon* for Australia.

V.—GENERA OF PLANTS IN LORD HOWE ISLAND.

Affinities of the Extra-Australian Genera.—The genus *Carmichaelia* contains nine species inhabiting New Zealand and one endemic in Lord Howe Island. *Colmeiroa* is a peculiar monotypic genus, the author of which approximates it to *Carpodetus*, a monotypic genus inhabiting New Zealand. *Acicalyptus* comprises the Lord Howe Island plant and two other species belonging to Fiji. *Negria* is another peculiar monotypic genus, having its nearest ally in *Rhabdothamnus*, which is

monotypic and belongs to New Zealand. *Clinostigma* has, besides the Lord Howe Island plant, some species in the Samoa Islands. *Hedyscepe* and *Howea*, dismembered from *Kentia*, are endemic.

Australasian Genera.—Of the twenty-nine genera in this category, the following five do not extend to New Zealand:—*Baloghia, Scaevola, Ochrosia, Lyonsia* and *Geitonoplesium.* Fourteen occur also in Norfolk Island, so that their relationships need not be repeated; of the remainder, *Dodonæa, Leptospermum, Pimelea, Brachycome, Cassinia,* and *Erechthites* exhibit an Australian facies, whilst *Dracophyllum* and *Uncinia* are characteristic of New Zealand.

The affinities of *Lagunaria* have already been discussed; whilst the genera *Rhagodia, Melaleuca* and *Westringia* are represented each by one species of continental origin.

Affinities with Norfolk Island.—The number of genera in Norfolk Island is 75, of which 53, or 70 per cent., are common to Lord Howe Island; of the remainder, *Melicytus, Meryta, Phormium* and *Rhopalostylis* attain their most northern and western limits in Norfolk Island; whilst *Eriostemon* and *Boronia* of Australian origin, *Viola* and *Osmunda* of cosmopolitan range, *Abutilon, Bryonopsis, Melothria, Melodinus, Freycinetia* and *Cordyline* of Oriental origin, *Bosistoa, Pseudomorus, Pennantia* and *Araucaria* of Polynesian origin seem to have missed Lord Howe Island in their respective lines of diffusion; the extension of *Procris* from the Indo-Malay region through Papua to Norfolk Island and Polynesia marks its southern limit. Excepting *Procris* and the first three of the above-named genera, all may reasonably be expected to occur in Lord Howe Island; these would bring the nominal number of genera common to the two insular floras to 67 or 90 per cent.

Conclusion.—Though there is a large number of New Zealand genera in the Lord Howe Island flora, yet the Australian forms preponderate; nevertheless it must be borne in mind that, whereas in Norfolk Island the majority of the more or less abundant genera in Australia are there represented by endemic species, in Lord Howe Island they are represented for the most part by continental species. One is tempted to suggest a modern immigration of Australian species which has dimmed the lustre of the original flora, as has been the case in a less marked degree in New Zealand.

Keeping in view the large community of genera between Lord Howe and Norfolk Islands, the former cannot be detached as a separate botanic region from the latter.

VI.—LIST OF GENERA COMPRISED IN THE FLORAS OF LORD HOWE AND NORFOLK ISLANDS, ARRANGED ACCORDING TO THEIR GEOGRAPHIC DISTRIBUTION.

[An asterisk (*) in the geographic columns indicates the region of the maximum development of the genus; a dagger (†), that a given species or genus occurs in the locality in question.]

I. *Extra-Australian.*

GENERA.	GEOGRAPHIC DISTRIBUTION. Lord Howe Island.	Norfolk Island.	New Zealand.	Polynesia.	Papua.	Oriental Province.
Melicytus	—	†	*	—	—	—
Ungeria	—	*	—	—	—	—
Procris	—	†	—	†	†	*
Carmichaelia	†	—	*	—	—	—
Streblorrhiza	—	*	—	—	—	—
Colmeiroa	*	—	—	—	—	—
Acicalyptus	†	—	—	*	—	—
Meryta	—	†	*	†	—	—
Negria	*	—	—	—	—	—
Phormium	—	†	*	—	—	—
Clinostigma	†	—	—	*	—	—
Hedyscepe	*	—	—	—	—	—
Rhopalostylis	—	*	*	—	—	—
Howea	*	—	—	—	—	—

II. *Australasian (essentially).*

GENERA.	GEOGRAPHIC DISTRIBUTION. Howe.	Norfolk.	Australia.	New Zealand.	Polynesia.	Papua.	Andean.	Oriental.
Drimys	†	†	†	†	†	—	†	Borneo.
Hymenanthera	†	†	†	†	—	—	—	—
Pittosporum	†	†	†	†	†	†	—	†
Baloghia	†	†	†	—	*	—	—	—
Pseudomorus‡	—	†	†	—	†	—	—	—
Dodonæa	†	—	*	†	—	—	—	—
Muehlenbeckia	†	†	†	†	†	†	†	—
Leptospermum	†	—	*	†	†	†	—	†
Metrosideros	†	†	*	†	†	—	—	—
Pennantia	—	†	†	†	—	—	—	—
Exocarpos	†	†	†	†	†	†	—	—
Pimelea	†	—	*	—	—	†	—	—
Coprosma	†	†	†	*	—	—	—	—
Brachycome	†	—	*	†	also S. Africa.			
Cassinia	†	—	*	†	also S. Africa.			
Erechthites	†	—	*	†	—	—	†	†
Scaevola	†	—	*	—	†	†	—	†
Geniostoma	†	—	†	†	†	—	—	—

‡ Monotypic genera.

GENERA.	Geographic Distribution.							
	Howe.	Norfolk.	Australia.	New Zealand.	Polynesia.	Papua.	Andean.	Oriental.
Ochrosia	†	—	†	—	†	†	—	—
Lyonsia	†	—	*	—	†	—	—	—
Myoporum	†	†	*	†	†	—	—	†
Leucopogon	†	—	†	†	†	—	†	—
Dracophyllum	†	—	†	*	†	—	—	—
Araucaria	—	†	†	—	†	†	†	—
Microtis	†	†	*	†	†	—	—	—
Dianella	†	†	*	†	†	—	—	†
Geitonoplesium‡	†	†	†	—	†	—	—	—
Uncinia	†	—	†	*	†	—	†	—
Dichelachne	†	†	*	*	—	—	—	—
Spinifex	†	—	*	†	†	—	—	†
Echinopogon‡	†	—	†	†	—	—	—	—
Tmesipteris‡	†	†	†	†	†	—	—	—

‡ Monotypic genera.

III. *Australian (exclusively, or nearly so).*

GENERA.	Howe.	Norfolk.
Boronia	—	†
Eriostemon	—	†
Bosistoa	—	†
Lagunaria	†	†
Rhagodia	†	—
Melaleuca	†	—
Westringia	†	—

N.B.—*Melaleuca* is represented by 103 species in Australia, one of which *(M. leucadendron)* extends to Papua and the Indian Archipelago; *M. ericifolia* extends to Lord Howe Island; the only exoteric species is *M. Brongniartii*, F.v.M., inhabiting New Caledonia,

IV.—*Cosmopolitan Genera.*

GENERA.	Howe.	Norfolk.	GENERA.	Howe.	Norfolk.
Clematis	†	—	Plantago	†	—
Lepidium	†	—	Convolvulus	†	†
Viola	—	†	Solanum	†	†
Oxalis	†	—	Iris	†	—
Euphorbia	†	†	Juncus	†	—
Parietaria	†	—	Luzula	†	—
Atriplex	†	—	Cyperus	†	†
Mesembrianthemum	†	—	Scirpus	†	—
Tetragonia	†	†	Cladium	†	—
Hydrocotyle	†	—	Carex	†	†
Apium	†	†	Agrostis	†	—
Viscum	†	†	Poa	†	—
Aster	†	—	Phragmites	†	—
Gnaphalium	†	—	Agropyron	†	—
Senecio	†	—	Lycopodium	†	†
Bidens	†	—	Selaginella	†	—
Lobelia	†	—	Trichomanes	†	†
Wahlenbergia	†	—	Hymenophyllum	†	†

Genera.	Howe.	Norfolk.
Cyathea	†	—
Osmunda	†	—
Dicksonia	†	†
Adiantum	†	—
Cheilanthes	†	†
Pteris	†	†
Lomaria	†	†
Woodwardia	†	—
Asplenium	†	—
Aspidium	†	—
Polypodium	†	†

v.—*Oriental Genera.*

Genera.	Howe.	Norfolk.
Cryptocarya	†	—
Stephania	†	—
Xylosma	†	—
Dysoxylum	†	†
Euodia	†	†
Xanthoxylum	†	†
Acronychia	†	†
Pelargonium	†	—
Abutilon	—	†
Hibiscus	†	†
Hemicyclia	†	—
Omalanthus	†	—
Celtis	†	†
Ficus	†	—
Malaisia	†	†
Elatostemma	†	—
Boehmeria	†	†
Piper	†	†
Peperomia	†	†
Cupania	†	—
Nephelium	†	—
Elæodendron	†	†
Achyranthes	†	†
Sesuvium	†	—
Boerhaavia	†	—
Pisonia	†	†
Mucuna	†	—
Canavalia	†	—
Vigna	†	—
Sophora	†	—
Cæsalpina	†	—
Panax	†	—
Randia	†	—
Psychotria	†	—
Passiflora	†	†
Bryonopsis	—	†
Melothria	—	†
Sicyos	†	—
Wedelia	†	—
Myrsine	†	†
Ægiceras	†	—
Sideroxylon	†	†
Symplocos	†	—
Jasminum	†	—
Olea	†	†
Mayepa	†	—
Melodinus	—	†
Alyxia	†	†
Tylophora	†	†
Marsdenia	†	—
Ipomœa	†	†
Tecoma	†	—
Eranthemum	†	—
Avicennia	†	—
Dendrobium	†	—
Bulbophyllum	†	—
Halophila	†	—
Crinum	†	—
Smilax	†	†
Cordyline	—	†
Pandanus	†	†
Freycinetia	—	†
Commelina	†	—
Flagellaria	†	—
Panicum	†	—
Oplismenus	†	—
Sporobolus	†	†
Cynodon	†	—
Psilotum	†	—
Marattia	†	—
Alsophila	†	†
Davallia	†	†
Hypolepis	†	—
Platycerium	†	—

VII—Species of Lord Howe and Norfolk Islands in respect of their Geographical Distribution.

The following table summarises the affinities of the species in their geographical relationships, the details of which are given in the appended List of Species arranged according to their geographical distribution.

Regional Distribution.	Howe.		Norfolk.		Common to both.
I. Extra-Australian—					
Endemic	56	...	42	...	5
Extra-limital	9	...	11	...	4
II. Australasian	49	...	23	...	15
III. Oriental and Cosmopolitan	59	...	8	...	7
IV. Australian—					
Extra-Australian genera	26	...	5	...	2
Australian genera	8	...	1	...	1
Total	207	...	90	...	34

VIII.—Species of Plants in Norfolk Island.

Of the total of 90 species 37 are common to Australia and Norfolk Island, leaving 53, or 59 per cent., which are absent from continental Australia. Of the eleven extra-Australian species not endemic, nine occur in New Zealand (three of which extend to Polynesia); the others are common to Polynesia and Norfolk Island. Of the continental species, five belong to cosmopolitan or Oriental genera, whilst the sixth, *Lagunaria Patersoni*, as remarked under the generic heading, may be regarded as having originated in either area. *Hymenanthera Banksii*, F.v.M., is a collective species including *H. dentata*, R.Br., *H. angustifolia*, R.Br., and *H. latifolia*, Endlicher; but Bentham considers the last distinct from the former two and from the New Zealand species; this view I have adopted, and so *H. latifolia* appears as a peculiar species in Schedule 1.

In comparing the specific elements of this flora we may confine ourselves, firstly to the extra-Australian non-endemic species and the continental ones; of the former there are eleven, of which nine are also in New Zealand; of the latter there are six, reducible to five by elimination of *Lagunaria Patersoni*, from which it appears that the larger community of species is greater with New Zealand than with Australia. In the second place, the large proportion of endemic species, nearly one-half, still further isolates this flora from Australia, though almost equally so from New Zealand; but viewed in the light of the generic facies, which is decidedly pronounced in favour of New Zealand, the flora of Norfolk Island must be regarded as a satellite of that of New Zealand.

The fragmental nature of the flora is indicated by the low ratio of the species to the genera; thus there are 90 species belonging to 76 genera, or 1·25 species to a genus; the genera with more than one species are:—*Eriostemon*, 2; *Euphorbia*, 3; *Peperomia*, 4; *Meryta*, 2; *Coprosma*, 2; *Olea*, 2; *Ipomœa*, 3; *Alsophila*, 2; *Pteris*, 2; and *Polypodium*, 2.

The community of species between Norfolk Island and Lord Howe Island is 34 out of 90, or 40 per cent.—certainly not large, but if we eliminate the endemic species, of which there are only five in common, then the community is about 60 per cent.

IX.—SPECIES OF PLANTS IN LORD HOWE ISLAND.

The total recorded species is 207, belonging to 154 genera, or about 1·34 species to a genus—very little in excess of the ratio for Norfolk Island. The number of species peculiar and non-Australian is 65, or 31·4 per cent., being nearly one-half less than the proportion for Norfolk Island. The affinity of the species is certainly greater with Australia than with any other region of the Australasian Province; and if we were to disregard the neighbouring floras, then that of Lord Howe Island might be accepted as part of eastern continental Australia. But as the flora presents certain marked affinities with that of New Zealand, and keeping in mind the large community of species between Norfolk Island and Lord Howe Island, and the fairly well marked affinity generically with Norfolk Island and New Zealand, there is no choice but to regard Lord Howe Island as a companion outlier to Norfolk Island of the New Zealand region.

It cannot have escaped notice that there is a general absence in the Lord Howe Island flora of the characteristic Australian types, and that there is no indication in the relationship of the flora to that of Papua of a land-connection between these two islands, as has been suggested because of the comparative shallow soundings which connect one with the other and Lord Howe Island with New Zealand. Unfortunately the geology of Lord Howe and Norfolk Islands does not help us to solve the problem of the date of the isolation of these insular masses, though Professor David has ventured the opinion that the volcanic material, which is the subterstructure of Lord Howe Island, is probably of not older date than Tertiary. The antiquity of the land-surface of Lord Howe Island would permit of the reception of Australian immigrants, since its severance from an extended New Zealand area, in greater numbers than would be possible to the more distant Norfolk Island; though in earlier times it may have also been a line of intercommunication between continental Australia and what is now New Zealand.

X.—LIST OF THE PLANT-SPECIES OF LORD HOWE AND NORFOLK ISLANDS, ARRANGED ACCORDING TO THEIR GEOGRAPHIC RELATIONSHIPS.

I. *Species Endemic.*

	Howe.		Norfolk.
Drimys Howeana, *F. v. Mueller*	†	...	†
Hymenanthera latifolia, *Endlicher*	†	...	†
Pittosporum bracteolatum, *Endl.*	—	...	†
Pittosporum erioloma, *C. Moore & F.v.M.*	†	...	—
Dysoxylum Patersoni, *Bentham & J. Hooker*	—	...	†
Boronia Barkeriana, *F.v.M.*	—	...	†
Eriostemon ambiens, *F.v.M.*	—	...	†
Eriostemon Beckleri, *F.v.M*	—	...	†
Bosistoa euodiformis, *F.v.M*	—	...	†
Euodia contermina, *C. Moore & F.v.M.*	†	...	—
Euodia littoralis, *Endl.*	—	...	†
Euodia polybotrya, *C. Moore & F.v.M.*	†	...	—
Xanthoxylum Blackburnia, *Benth.*	†	...	†
Xanthoxylum Howeanum, *? C. Moore & F.v.M.*	†	...	—
Acronychia Endlicheri, *Schott*	—	...	†
Abutilon Julianæ, *Endl.*	—	...	†
Hibiscus insularis, *Endl.*	—	...	†
Ungeria floribunda, *Schott & Endl.*	—	...	†
Euphorbia obliqua, *Bauer*	—	...	†
Celtis amblyphylla, *F.v.M.*	†	...	—
Ficus columnaris, *F.v.M. & C. Moore*	†	...	—
Procris montana, *Steudel*	—	...	†
Boehmeria australis, *Endl.*	—	...	†
Boehmeria calophleba, *C. Moore & F.v.M.*	†	...	—
Elæodendron curtipendulum, *Endl.*	—	...	†
Achyranthes arborescens, *R. Brown*	—	...	†
Carmichaelia exsul, *F.v.M.*	†	...	—
Streblorrhiza speciosa, *Endl.*	—	...	†
Colmeiroa carpodetoides, *F.v.M.*	†	...	—
Metrosideros nervulosa, *C. Moore & F.v.M.*	†	...	—
Metrosideros polymorpha, *Gaudichaud*	†	...	†
Acicalyptus Fullagari, *F.v.M.*	†	...	—
Panax Cissodendron, *C. Moore & F.v.M.*	†	...	—
Meryta angustifolia, *Seemann*	—	...	†
Meryta latifolia, *Seem.*	—	...	†
Pennantia Endlicheri, *Reisseck*	—	...	†
Exocarpos homaloclada, *C. Moore & F.v.M.*	†	...	—
Exocarpos phyllanthoides, *Endl.*	—	...	†
Randia stipularis, *F.v.M.*	†	...	—
Psychotria Carronis, *C. Moore & F.v.M.*	†	...	—
Coprosma lanceolaris, *F.v.M*	†	...	—

	Howe.		Norfolk.
Coprosma putida, *C. Moore & F.v.M.*	†	...	—
Coprosma pilosa, *Endl.*	—	...	†
Passiflora glabra, *Wendland*	—	...	†
Melothria Baueriana, *F.v.M.*	—	...	†
Brachycome segmentosa, *C. Moore & F.v.M.*	†	...	—
Aster Balli, *F.v.M.*	†	...	—
Aster Mooneyi, *F.v.M.*	†	...	—
Cassinia tenuifolia, *Benth.*	†	...	—
Senecio insularis, *Benth.*	†	...	—
Geniostoma petiolosum, *C. Moore & F.v.M.*	†	...	—
Myrsine platystigma, *F.v.M.*	†	...	—
Sideroxylum costatum, *Endl.*	—	...	†
Sideroxylum Howeanum, *F.v.M.*	†	...	—
Olea Endlicheri, *Britten*	—	...	†
Mayepea quadristaminea, *F.v.M.*	†	...	—
Melodinus Baueri, *Endl.*	—	...	†
Alyxia gynopogon, *Roem. & Schultes*	—	...	†
Alyxia Lindii, *F.v.M.*	†	...	—
Alyxia squamulosa, *C. Moore & F.v.M.*	†	...	—
Tylophora biglandulosa, *A. Gray*	—	...	†
Tylophora enervis, *F.v.M.*	†	...	—
Marsdenia tubulosa, *F.v.M.*	†	...	—
Ipomœa cataractæ, *Endl.*	—	...	†
Solanum Bauerianum, *Endl.*	†	...	†
Negria rhabdothamnoides, *F.v.M.*	†	...	—
Myoporum obscurum, *Endl.*	—	...	†
Dracophyllum Fitzgeraldi, *F.v.M.*	†	...	—
Araucaria excelsa, *R.Br.*	—	...	†
Dendrobium Moorei, *F.v.M.*	†	...	—
Iris Robinsoniana, *F.v.M.*	†	...	—
Cordyline obtecta, *Baker* (C. Baueri, *J. Hooker*)	—	...	†
Howea Belmoreana, *C. Moore & F.v.M.* (Kentia)	†	...	—
Howea Forsteriana, *C. Moore & F.v.M.* (Kentia)	†	...	—
Hedycepe Canterburyana, *C. Moore & F.v.M.* (Kentia)	†	...	—
Rhopalostylis Baueri, *Seem.* (Kentia)	—	...	†
Clinostigma Mooreanum, *F.v.M.*	†	...	—
Pandanus Forsteri, *C. Moore & F.v.M.*	†	...	—
Pandanus Moorei, *F.v.M.*	—	...	†
Luzula longiflora, *Benth.*	†	...	—
Cyperus hæmatodes, *Endl.*	†	...	†
Cladium insulare, *Benth.*	†	...	—
Uncinia debilior, *F.v.M.*	†	...	—
Carex Neesiana, *Endl.*	—	...	†
Cyathea brevipinna, *Baker*	†	...	—
Cyathea Macarthurii, *F.v.M.*	†	...	—
Cyathea Moorei, *F.v.M.*	†	...	—
Osmunda Moorei, *F.v.M.*	†	...	—
Dicksonia nephrodioides, *Baker*	†	...	—
Lomaria Fullagari, *F.v.M.*	†	...	—
Asplenium melanochlamys, *Hook.*	†	...	—
Asplenium pteridoides, *Baker*	†	...	—

II. *Species Extra-Australian.*

	Howe.	Norfolk.	New Zealand.	Polynesia.	Papua.
Melicytus ramiflorus, *R. & G. Forster*	—	†	†	—	—
Euphorbia Tannensis, *Sprengel* (E. Norfolkiana, *Boissier*)	—	†	—	†	—
Piper excelsum, *G. Forst.*	†	†	†	†	—
Peperomia Urvilleana, *A. Richard*	†	†	†	†	—
Muehlenbeckia australis, *Meissner*	—	†	†	—	—
Sophora tetraptera, *J. Miller*	†	—	†	—	—
Pimelea longifolia, *Banks & Solander*	†	—	†	—	—
Coprosma Baueri, *Endl.*	†	†	†	—	—
Bryonopsis affinis, *Naudin*	—	†	—	†	—
Phormium tenax, *R. & G. Forst*	—	†	†	—	—
Smilax purpurata, *G. Forst.*	†	—	—	†	—
Dianella intermedia, *Endl.*	—	†	†	†	—
Freycinetia Baueriana, *Endl.*	—	†	†	—	—
Cladium (Gahnia) xanthocarpum, *F.v.M.*	†	—	†	—	—
Hymenophyllum multifidum, *Swartz*	†	†	†	†	—
Lomaria attenuata, *Willdenow*	†	—	†	†	Trop.Am.

III. *Species Australasian, found in Australia, but essentially Polynesian and New Zealandian or widely distributed.*

	Howe.	Norfolk.	New Zealand.	Polynesia.	Papua.
Clematis glycinoides, *De Candolle*	†	—	—	†	—
Acronychia Baueri, *Schott*	†	—	—	†	—
Pelargonium australe, *Willd.*	†	—	†	—	—
Baloghia lucida, *Endl.*	†	†	—	†	—
Euphorbia Sparmanni, *Boiss.*	†	†	†	†	—
Pseudomorus Brunoniana, *Bureau*	—	†§	—	†§	—
Peperomia Baueriana, *Miquel* (P. adscendens, *Endl.*)	—	†	—	—	—
Peperomia leptostachya, *Hook. & Arnott*	†	†	—	†	—
Dodonæa viscosa, *Linné*	†	—	†	†	†
Tetragonia expansa, *Murray*	†	†	†	—	—
Tetragonia implexicoma, *J. Hook.*	†	—	†	—	—
Muehlenbeckia axillaris, *J. Hook.*	†	—	†	—	—
Pisonia Brunoniana, *Endl.*	†	†	†	—	†
Erechtites quadridentata, *DC.*	†	—	†	—	—
Lobelia anceps, *Thunberg*	†	—	†	—	S. Af. / S. Am.
Olea paniculata, *R.Br.*	†	†	—	†	—
Ochrosia elliptica, *Labillard.*	†	—	—	†	—
Jasminum didymum, *G. Forst.*	†	—	—	†	†
Jasminum simplicifolium, *G. Forst.*	†	—	—	†	—
Ipomœa bona-nox, *Linné*	†	†	—	†	—
Ipomœa congesta, *R.Br.*	—	†	—	†	—

§ Represented by var. *pendulina*; var. *australiana* is continental, and var. *obtusata* belongs to New Caledonia.

	Howe.	Norfolk.	New Zealand.	Polynesia.	Papua.
Convolvulus marginatus, *Poiret*	†	†	†	—	—
Symplocos Stawellii, *F.v.M.*	†	—	—	†	—
Solanum aviculare, *G. Forst.*	†	—	†	—	—
Microtis porrifolia, *R. Br.*	†	†	†	—	—
Geitonoplesium cymosum, *Cunningham*	†	†	—	†	—
Dichelachne crinita, *J. Hook*	†	—	†	—	—
Dichelachne sciurea, *J. Hook*	—	†	†	—	—
Agrostis Solandri, *F.v.M.*	†	—	†	—	—
Echinopogon ovatus, *Palisot*	†	—	†	—	—
Poa cæspitosa, *G. Forst.*	†	—	†	—	—
Agropyrum scabrum, *Pal.*	†	—	†	†	—
Tmesipteris Tannensis, *Bernhardi*	†	†	†	†	—
Lycopodium varium, *R.Br.*	†	—	†	†	—
Lycopodium densum, *Labill.*	—	†	†	—	—
Hymenophyllum nitens, *R.Br.*	†	—	†	—	—
Hymenophyllum Tunbridgense, *Smith*	†	—	†	—	—
Davallia dubia, *R.Br.*	†	—	—	†	—
Davallia pyxidata, *Cavan.*	—	†	—	†	—
Cheilanthes distans, *A. Braun*	†	†	†	†	—
Pteris comans, *G. Forst.*	†	—	†	†	—
Pteris rotundifolia, *G. Forst.*	—	†	†	—	—
Pteris tremula, *R. Br.*	†	†	†	†	—
Lomaria discolor, *Willd.*	—	†	†	—	—
Aspidium decompositum, *Spreng.*	†	—	†	†	—
Polypodium australe, *Mettenius*	†	—	†	—	And.
Polypodium pustulatum, *G. Forst.*	†	—	†	†	—
Polypodium tenellum, *G. Forst.*	†	†	†	†	—

The following species are essentially maritime :—

	Howe.	Norfolk.	New Zealand.	Polynesia.	Papua.
Lepidium foliosum, *Desvaux*	†	—	†	—	—
Mesembrianthemum australe, *Sol.*	†	—	†	†	—
Mesembrianthemum æquilaterale, *Haworth*	†	—	†	—	—
Apium prostratum, *Labill.*	†	†	†	†	—
Leucopogon Richei, *R.Br.*	†	—	†	—	—
Juncus maritimus, *Lamarck*	†	—	†	†	—
Scirpus nodosus, *Rottboell*	†	—	†	—	—
Spinifex hirsutus, *Labill.*	†	—	†	—	—
Asplenium obtusatum, *Forst.*	†	—	†	—	—

IV. *Oriental and Cosmopolitan Species occurring in Australia and the majority in Polynesia.*

	Howe.	Norfolk.
Stephania hernandifolia, *Walpers*	†	—
Oxalis corniculata, *Linné*	†	—
Hibiscus diversifolius, *N. Jacquin*	†	—
Hemicyclia sepiaria, *Wight & Arnott*	†	—

	Howe.		Norfolk.
Omalanthus Leschenaultianus, *A. Jussieu*	†	...	—
Celtis paniculata, *Planchon*	†	...	†
Malaisia tortuosa, *Blanco*	†	...	†
Parietaria debilis, *G. Forst*	†	...	—
Peperomia reflexa, *A. Dietrich*	†	...	†
Achyranthes aspera, *Linné*	†	...	—
Sesuvium portulacastrum, *Linné*	†	...	—
Boerhaavia diffusa, *Linné*	†	...	—
Mucuna gigantea, *DC*	†	...	—
Leptospermum flavescens, *Sm*	†	...	—
Viscum articulatum, *Burmann*	†	...	†
Sicyos angulata, *Linné*	†	...	—
Gnaphalium Japonicum, *Thunb*	†	...	—
Gnaphalium luteo-album, *Linné*	†	...	—
Wedelia biflora, *DC*	†	...	—
Bidens pilosus, *Linné*	†	...	—
Wahlenbergia gracilis, *DC*	†	...	—
Ipomœa palmata, *Forskael*	†	...	—
Flagellaria Indica, *Linné*	†	...	—
Carex breviculmis *R.Br*	†	...	—
Panicum sanguinale, *Linné*	†	...	—
Oplismenus compositus, *Pal*	†	...	—
Sporobolus Indicus, *R.Br*	†	...	†
Cynodon dactylon, *Rich*	†	...	—
Phragmites communis, *Trin*	†	...	—
Psilotum triquetrum, *Swartz*	†	...	—
Marattia fraxinea, *Sm*	†	...	—
Trichomanes apiifolium, *Prest*	†	...	†
Dicksonia davallioides, *R.Br*	—	...	†
Adiantum Ethiopicum, *Linné*	†	...	—
Adiantum hispidulum, *Swartz*	†	...	—
Cheilanthes tenuifolia, *Swartz*	†	...	—
Pteris falcata, *R.Br*	†	..	—
Pteris aquilina, *Linné*	†	...	—
Pteris incisa, *Thunb*	†	...	—
Lomaria Capensis, *Willd*	†	...	—
Asplenium nidus, *Linné*	†	..	—
Asplenium falcatum, *Lam*	†	...	—
Aspidium cordifolium, *Swartz*	†	...	—
Aspidium molle, *Swartz*	†	...	—
Aspidium Capense, *Willd*	†	...	—
Polypodium Hookeri, *Brackenridge*	†	...	—
Polypodium confluens, *R.Br*	†	...	†
Polypodium punctatum, *Thunb*	†	...	—
Hypolepis tenuifolia, *Bernh*	†	...	—
Platycerium alcicorne, *Desv*	†	...	—

The following species are essentially maritime :—

	Howe.		Norfolk.
Hibiscus tiliaceus, *Linné*	†	...	—
Canavalia obtusifolia, *DC*	†	...	—
Vigna lutea, *A. Gray*	†	...	—
Cæsalpina Bonducella, *Fleming*	†	...	—
Scævola Koenigii, *Vahl*	†	...	—
Ægiceras majus, *Gaertner*	†	...	—
Ipomœa pes-capræ, *Roth*	†	...	—
Convolvulus Soldanella, *Linné*	†	...	—
Avicennia officinalis, *Linné*	†	...	—
Halophila ovata, *Gaud*	†	...	—

v. *Australian Species of Extra-Australian Genera (for the most part Oriental).*

	Howe.		Norfolk.		Papua.
Cryptocarya triplinervis, *R.Br*	†	...	—	...	—
Viola betonicifolia, *Sm*	—	...	†	...	—
Xylosma ovata, *Benth*	†	...	—	...	—
Dysoxylum Fraserianum, *Benth*	†	...	—	...	—
Elatostemma reticulatum, *Weddell*	†	...	—	...	†
Cupania anacardioides, *Rich*	†	...	—	...	—
Nephelium semiglaucum, *F.v.M*	†	...	—	...	—
Elæodendron australe, *Ventenat*	†	...	—	...	—
Atriplex cinereum, *Poir*	†	...	—	...	—
Hydrocotyle hirta, *R.Br*	†	...	—	..	—
Passiflora Hebertiana, *Lindley*	†	...	—	...	—
Plantago varia, *R.Br*	†	...	—	...	—
Myrsine crassifolia, *R.Br*	†	...	†	...	—
Sideroxylum australe, *Benth. & Hook*	†	...	—	...	—
Alyxia ruscifolia, *R.Br*	†	...	—	...	†
Marsdenia rostrata, *R.Br*	†	...	—	...	—
Tecoma australis, *R.Br*	†	...	—	...	—
Eranthemum variabile, *R.Br.*	†	...	—	...	†
Dendrobium gracilicaule, *F.v.M*	†	...	—	...	—
Bulbophyllum exiguum, *F.v.M*	†	...	—	...	—
Crinum pedunculatum, *R.Br*	†	...	—	...	—
Smilax glycyphylla, *Sm*	—	...	†	...	—
Smilax australis, *R.Br*	†	...	—	...	—
Commelina cyanea, *R.Br*	†	...	—	...	†
Carex gracilis, *R.Br*	†	...	—	...	—
Selaginella uliginosa, *Spring*	†	...	—	...	—
Alsophila australis, *R.Br*	†	...	†	...	—
Alsophila excelsa, *R.Br*	—	...	†	...	—
Woodwardia aspera, *Mett*	†	...	—	...	—

VI. *Australian Species of Australasian Genera.*

	Howe.		Norfolk.
Lagunaria Patersoni, *G. Don*	†	...	†
Rhagodia Billardieri, *R.Br.*	†	...	—
Melaleuca ericifolia, *Sm.*	†	...	—
Brachycome diversifolia, *Fischer & Meyer*	†	...	—
Lyonsia reticulata, *F.v.M.*	†	...	—
Westringia rosmariniformis, *Sm.*	†	...	—
Myoporum insulare, *R.Br.*	†	...	—
Dianella cærulea, *Sims*	†	...	—

POSTSCRIPT :—My deductions will be found to confirm the views enunciated by Mr. C. Moore in a paper entitled "Remarks on the Botany of Lord Howe Island" in Vol. V. (for 1871) of the Transactions of the Royal Society of New South Wales, of the existence of which I was unaware until my attention was called to it by the Editor of the Macleay Memorial Volume when the MS. of my paper was in the printer's hands. Like my informant, I have been unable to consult Mr. Moore's paper as published by the Royal Society of New South Wales, the volume containing it having been long out of print: my knowledge of it accordingly has been derived from a few extracts obligingly furnished by my correspondent from the paper as it appears—with certain statistical omissions—in the *Sydney Mail*, October 21st, 1871.—R.T.

NOTES ON AN UNDESCRIBED *ACACIA* FROM NEW SOUTH WALES.

BY BARON VON MUELLER, K.C.M.G., M. & PH.D., LL.D., F.R.S.

(Plate XXVIII.)

ACACIA MAIDENII.

Arborescent; branchlets somewhat angular towards the summit; phyllodes large, of chartaceous texture, lanceolar-falcate, gradually narrowed into the petiole, very closely striolated by fine longitudinal venules with some few of these more prominent, almost glabrous or slightly greyish from hardly visible hairlets; marginal glandule near the anterior base of the phyllode, inconspicuous; spikes almost sessile, solitary or two or three together, their rachis tomentellous; bracts inconspicuous; calyces broader than long, much shorter than their corolla, short-lobed, subtle-pubescent; corolla almost glabrous, deeply cleft into usually 4 lobes, not streaked; fruit narrow, considerably compressed, much twisted, outside beset with minute hairlets; seeds placed longitudinally, ovate-ellipsoid, shining-black, their aureole on each side large; funicle pale reddish, completely or extensively encircling the seeds, suddenly doubled back from the summit, folded at the lower side.

Near the Richmond River, (Mrs. Hodgkinson, W. Bäuerlen); Mooloolah River, (Eaves).

A tree to 50 feet high, with a stem-diameter of 1½ feet.

To the sagacity and circumspectness of Mr. J. H. Maiden it is due, that this Acacia became recognised as a species distinct from *A. glaucescens*, for which previously it had been passed. It is, however, clearly different in carpic characteristics particularly, inasmuch as the fruit of the genuine *A. glaucescens* is straight and still more compressed, the seeds are longer, but proportionately narrower, the funicle is almost colourless, and stretching only to the lower portion of the seed, there forming an arillar fold. Moreover, in *A. glaucescens* the phyllodes are less destitute of hairlets—an original specimen of Sieber's *A. cinerascens*, available here to me, being very instructive in this respect, and so an authentic specimen of Wendland's *A. homomalla*;—further the calyx is more decidedly velutinous, and the

corolla is usually five-lobed, not like that of *A. longifolia* and its allies fourcleft; but how far this note holds good, requires yet further to be ascertained. Already De Candolle, and later Hooker, seized on this characteristic, when briefly defining *A. cinerascens* of Sieber, who may have possibly perceived other distinctions between that supposed species and *A. glaucescens.* Sprengel, who one year later than De Candolle promulgated *A. cinerascens* by a diagnosis too brief, lays also stress on the characteristic of grey-velutinous branchlets, which does not apply to *A. Maidenii;* it is therefore unlikely that Mr. Maiden's plant should be connected by intermediate forms with *A. cinerascens*, which authentically was not gathered in fruit. Contrarily, Bentham seems to have been quite right in combining it with *A. glaucescens*, of which Mr. A. R. Crawford says, that the phyllodes of young plants are roundish. *A. leucadendron*, reduced by Bentham to *A. glaucescens*, represents perhaps also the form *cinerascens*, as in Hooker's Lond. Journ. I. 374, the spikes are called, probably by a mere writing error, semipollicares, instead of sesquipollicares (when fully developed); this can only be cleared up from Cunningham's collections.

Furthermore, it should be remarked, as pointed out by Mr. Maiden, that *A. glaucescens* is in the lowlands of New South Wales a southern species, while *A. Maidenii* is a northern, from regions not accessible to Sieber during his only seven months' Australian collecting visit to Port Jackson and its vicinity from June, 1822, to Jan., 1823. Here it may be of further interest to state, that a letter from Sieber appeared in the Ratisbon bot. Zeitung "Flora" of 1824, at pp. 250-256 and following, in which communication he speaks of the marvellous forms of Australian Acacias, specimens of about 150 species being shown him there and then by Allan Cunningham (F. C. Dietrich in Eichler's Jahrbuch, 1881, p. 287). But as yet the fruit of *A. cinerascens* remains unknown, to confirm absolutely the specific identity of that plant with *A. glaucescens.* The preponderance of 4- or 5-cleft corollas can best be ascertained by examining great masses of the flowers on living plants at their indigenous places. The localities, annotated under *A. glaucescens* in the Flora Australiensis, II. 406-407, for northern New South Wales and for Queensland, belong probably all to *A. Maidenii;* indeed, the most northern station for *A. glaucescens*, with certainty represented in the Melbourne Herbarium, is on the eastern slopes of New England at the Apsley River (A. R. Crawford), therefore in a cool region; while its southern known limit is at the Genoa on mountains (Bäuerlen). The very flexuous fruit of *A. Maidenii* resembles that of *A. implexa*, but the arillar funicles in that species are much like those of *A. glaucescens*, therefore basal only to the seeds.

A. Cunninghami comes very near to *A. Maidenii*, particularly also in the venulation of the phyllodes, though the main venules are more prominent; but the branchlets are very angular and more robust, the phyllodes more inequilateral and

thus indicate an approach to those of the *Dimidiatæ*, the calyces are nearly glabrous, the corollas are usually 5-cleft, necessitating a 5-denticulate calyx also, the fruits are still less broad, the seeds distinctly narrower but quite as long, the arillar appendage extends only to the basal part of the seed, and forms there a thick appendage from almost consolidated foldings of the funicle.

A. Cunninghami is evidently a more frequent species than *A. Maidenii;* thus it occurs in the distributed collections of Madame Dietrich from Port Mackay, Lake Elphinstone and Rockhampton under the following numbers, so far as can be judged from flowering samples, all her specimens being devoid of fruit: 254, 381, 486, 539, 553, 622, 851, 1651, 2502, 2539. The following localities are also additional to those recorded in 1864 in the second volume of the Flora Australiensis: Gwydir and Wide Bay (Leichhardt), Walloon (Bowman), Darling-Downs (Lau), Richmond River (Fawcett), Leichhardt-Downs (Wuth), Barcoo (Schneider). Confirmatory fruit-specimens are wanting also from all these localities, so that still some doubts may be entertained about the identifications, especially for the plants from the far inland-places.

A. holcocarpa, which has the venulation of *A. glaucescens*, is easily distinguished from *A. Maidenii* in various respects, particularly in its rigid almost cylindric somewhat furrowed fruit, dark brown turgid seeds and long straight funicle, ending in a very small nearly cupular aril, as shown in the eleventh decade of the Iconography of Australian Acacias. Mr. Dallachy noted this species as dwarf, the fresh flowers as fragrant and—strange to say—as white; so they must at all events be very pale; but Solander likewise indicated the flowers of *A. calyculata* as white, and thus the question arises whether perhaps the two species are identical.

Specimens, but in flower only, from Fitzroy Island (Walter) seem referable to *A. holcocarpa*, but they accord so far also fully with the description of Cunningham's plant from there; the fruit, sent with his flowering specimens, may really belong to the rather widely distributed *A. aulacocarpa.* Visitors to Fitzroy Island could easily solve this enigma. *A. holcocarpa* has become further known from Cape Sidmouth (C. Moore), Trinity Bay (W. Hill), Rockingham Bay and Hinchinbrook Island, where it is common (J. Dallachy). It seems to be essentially a plant of coastal regions. *A. leptocarpa* is distinguished from *A. Maidenii* in the phyllodes showing hardly any conspicuous anastomosing venulation, the interstices between the venules being also wider, in flowers less crowded along the rachis, in glabrous calyces, in generally 5-parted corollas, and in numerous almost consolidated folds of the funicle, these forming downward an appendicular mass of a length as great as the seed itself or even greater, though basal only; I find, however, the fruit-valves to a considerable extent flexuous. The phyllodes are without lustre. *A. julifera* resembles in close

venulation of the phyllodes *A. glaucescens,* from which it differs in phyllodes of a more falcate form, terminated by a callous glandule, which reminds of that of *A. stigmatophylla* and *A. leptocarpa,* by smaller spikes and deeper cleft calyces; but the fruit-specimens from Edgecombe Bay, alluded to by Bentham, may not perhaps belong to the same species, as they are nearer to *A. Cunninghami* also as regards foliage.

Mr. Bowman gives the height of *A. julifera* as only up to 10 feet at Nercool Creek and the Upper Flinders River, and says it is early flowering in the season. It is contained in Madame Dietrich's collection from Port Denison under 2812, mixed with *A. Solandri.* That species agrees in venulation of the phyllodes certainly with *A. julifera,* but the phyllodes are narrower and straighter, the spikes longer, with remarkably dissite flowers like in *A. aulacocarpa* and *A. cincinnata;* the calyces are short-lobed and glabrous, the fruit curled-flexuous, compressed, about $\frac{1}{6}$ inch broad, the seeds ellipsoid, the funicle forms folds, but reaches the lowest part of the seeds only.

A. cincinnata almost agrees, as regards carpologic characteristics, with *A. Maidenii,* but the phyllodes are somewhat dimidiate, more protracted upwards and more distinctly callous-glandular at the apex, reminding thus far of *A. julifera;* their two or three primary venules are more prominent, the rachis is less tomentose, the flowers are more distant in the spikes, the calyces are deeper lobed, the corollas generally 5-cleft, the fruits narrower and more closely coiled, the funicle is near the base of the seed more folded.

All the species mentioned may differ from each other besides in habit, predilection of places of growth, bark, wood, odour of blossoms, time of flowering, as also fruiting, and perhaps in some other respects not observable on mere dried branchlets.

EXPLANATION OF PLATE.

Fig 1.—Unexpanded flower.

Figs. 2 and 3.—Expanded flower.

Fig. 4.—Different views of stamens.

Fig. 5.—Pistil.

Fig. 6.—Pod.

Fig. 7.—Seeds with arillus.

Fig. 8.—Part of a phyllodium.

All magnified except fig. 6.

DESCRIPTION OF A NEW *HAKEA* FROM EASTERN NEW SOUTH WALES.

By Baron von Mueller, K.C.M.G., M. & Ph.D., LL.D., F.R.S., and J. H. Maiden, F.L.S.

(Plate xxix.)

Hakea Bakeriana, F.v.M. & Maiden.

Branchlets slightly pubescent; leaves crowded, thinly filiform, undivided, simply acute, moderately pungent, glabrous or nearly so; flowers of rather large size, fasciculate, glabrous, their peduncle conspicuous, slightly beset with hairlets and bearing several scattered permanently undeveloped flowerbuds with pubescent very short yet broad bracts; pedicels about half as long as the petals and as well as these pale rosy-red, except the whitish summit; style very much longer than the petals; stigma lateral; ovulary on a short and thick stipes; fruit extremely large, almost globular-ovate, verrucular at and towards the upper end, elsewhere somewhat rugular; seed-membrane exceedingly extensive, oblique-ovate, rather broadly surrounding both sides and also the base of the nucleus, the latter being nearly smooth.

On a barren patch of ground close to the bank of a creek at Wallsend, near Newcastle, New South Wales. Soil sandy loam. Not very abundant in this locality, probably rare. The largest plant seen about 6 feet high with a stem of 1 inch in diameter, forming a bushy, ornamental shrub. Seen in flower July to September. Leaves 2-5 inches long, furrowless. Peduncle often $\frac{1}{2}$ inch long. Petals, by adding their terminal curvature, about $\frac{2}{3}$ inch long. Style up to almost 2 inches in length. Fruit up to 3 inches long and 2 inches broad, very turgid. Seeds $\frac{1}{3}$-$\frac{1}{2}$ inch long, their membrane being $\frac{3}{4}$ to 1 inch in width at its broadest part.

It is nearest allied to *H. purpurea;* but the leaves of that species are nearly always doubly forked, while their divisions are thicker and sharply pointed, the flower-fascicles almost sessile, the fruits conspicuously smaller. The new species, as regards size of fruit, comes among East Australian congeners near *H. Macraeana*, which, however, has leaves underneath uni-furrowed, the flowers quite small, the fruit compressed towards the summit, and the seed-membrane much less extending to the nucleus. *H. propinqua* has shorter and more rigid leaves, minute flowers on

pubescent pedicels, more verrucular fruits and the seed-membrane decurrent only along one side of the nucleus. In the last-mentioned characteristic *H. verrucosa* also differs, besides in evidently smaller fruits with two conic terminations, but the flowers are very similar, though the peduncles are tomentellous. Leaves of *H. rhombales* (a North-West Australian species) longer, flowers distinctly smaller, style hardly half as long, fruits of less size, seed-membrane much shorter and very inequilateral, nucleus verrucular rough on the outer side.

This species is dedicated to Mr. R. T. Baker, Assistant Curator of the Technological Museum, who exercises his artistic skill in the delineation of New South Wales indigenous plants.

EXPLANATION OF PLATE.

Fig. 1.—Part of plant showing dehiscent fruit with carpel *in situ*.

Fig. 2.—Fascicles of flowers unexpanded.

Fig. 3.—Fascicles of flowers fully expanded.

Fig. 4.—Single flower enlarged; part of the petals cut away to show gland at the base of the style.

Fig. 5.—Pollen grain, enlarged.

Fig. 6.—Fruit before dehiscing.

Fig. 7.—Fruit showing seeds.

A DESCRIPTION OF SOME OF THE IMPLEMENTS AND WEAPONS OF THE ALLIGATOR TRIBE, PORT ESSINGTON, NORTH AUSTRALIA.

By R. ETHERIDGE, JUNR., PALÆONTOLOGIST TO THE AUSTRALIAN MUSEUM, AND GEOLOGICAL SURVEY OF NEW SOUTH WALES.

(Plates xxx.-xxxv.)

CONTENTS.

The Collection of Weapons, Implements, and some Articles of Dress from the Alligator Tribe, Port Essington, were collected by Mr. Harry Stockdale, and have been forwarded to the Chicago Exhibition by the New South Wales Commissioners. The following notes and drawings were prepared in conjunction with Mr. Charles Hedley, F.L.S., and are now published at the desire, and with the permission of the Chairman (Dr. J. C. Cox, &c.) of Committee XI. (Liberal Arts, &c.) of the N. S.

Wales Commission, World's Columbian Exposition, Chicago, 1893. I need only add that our thanks are due to Mr. Stockdale for the native names of many of the specimens, numerous items of information regarding their uses, &c., and for the original drawings of Pl. xxxv.

The articles described in the following pages are of more than ordinary interest, for I believe they are the most complete set that have yet been noticed from any one Australian tribe *per se,* and from the fact that several of the specimens are now for the first time brought under notice.

The three Alligator Rivers, East, South, and West, fall into the south-eastern corner of Van Diemen Gulf, within the boundary of the Northern Territory of the Province of South Australia. We are informed by the late Mr. George Windsor Earl* that the lower parts of the Alligator Rivers are occupied by the Bimbirik Tribe, a comparatively large community, and it is more than probable that this is the Aboriginal name for the former possessors of the present weapons and implements. Mr. Stockdale coincides in this opinion. The neighbours of the Bimbirik people on the east of the Coburg Peninsula are called Jalakuru, whilst the tableland to the south is occupied by a still more powerful tribe called the Marigianbirik, or "People of the Mountains."

In the following pages the weapons will be described first, followed by the implements and articles of dress.

I.—Weapons.

Spears.

The North Coast spears generally seem to be remarkable for their more or less ornate carving and gaudy colouring, thus standing out in strong contrast to those used by the Aborigines of the southern part of the Continent.

Foremost amongst the spears is the *All-eitch,* or stone headed spear, consisting of sapling or reed shafts, coloured with red pigment or ruddle,† and moderately short stone heads of flesh-coloured granular quartzite. I have already figured‡ one of these heads from Settlement Creek, and the reader is referred to the description accompanying it for descriptive particulars. The quartzite heads are held in place by gum-cement§ and native twine, the latter coated with clay and coloured white with

* Journ. R. Geogr. Soc., 1846, XVI. p. 242.

† The methods of preparing this widely distributed article of personal adornment and ornamental use would form the subject of an essay alone.

‡ P.L.S.N.S.W., 1891, VI. (2), p. 37, t. 4, f. 2.

§ The composition of this most excellent cement differs widely in various parts of the Continent. There were a least half-a-dozen different recipes known to the Blacks.

pipeclay, or with white transverse bands. One of these spears has a slate-rock head in place of the quartzite, and being in an unfinished state displays the mode of manufacture, the gum and string lashing being present, but no pipeclay covering or colouration. The longest spear is eight and a-half feet, the shortest seven feet, and the average length eight feet.

This is unquestionably the "war spear of the North Coast" figured by Eyre,* having a quartzite head six inches long, and exceeding in total length the previous measurements, being nine and a-half feet, but a still more formidable variety of this spear is one figured by the same author in which the stone head is jagged.† The late R. B. Smyth also makes a reference to these north coast spears, remarking‡:—"They are ornamented with longitudinal grooves in bands alternating with plain spaces, and the colours used are red, yellow, and white, the white often appearing in dots on the other colours. The weight of these spears varies from ten ounces to eleven and three-quarter ounces." For the heads Smyth gives the length eight inches, and for the shafts nine to nine feet six inches.

The *All-eitch*, or war spear, is thrown with the *Orro-korr-ok*, or sabre womerah, according to Mr. Stockdale, the proximal end of the shaft being cup-shaped for the reception of the womerah-tooth, lashed round with twine, covered with gum-cement, and whitened like the stone heads. On the other hand, that very careful observer Macgillivray says a stiff flat womerah, the *Billetta* probably, is used.§ The quartzite, adds he, is procured from the mountains behind the Port Essington isthmus. The stone-headed or war spear of the Kimberley district, termed *Killawal* by Hardman,‖ the latter says, is thrown by the *Gnalealing* [= *Billetta*] womerah, which lends support to Macgillivray's statement. My deceased friend states that it is "only in the north that flint is used as a spear-head proper; and this custom, I may say, extends across the whole of the northern portion of Australia generally. But below from 20° to 30° south latitude wooden spears prevail. Among the many tribes it is the custom to insert rough chips of basalt or hard metamorphic rock, and in latter days glass, along the edges of the spear-heads, but it is only the most northern tribes who tip their weapons with single flint-heads."¶

An interesting but small group of spears, five in number, used both for fighting and hunting, are made either of saplings or reeds, and tipped with very sharply pointed and round hardwood heads. The shafts are ruddled, and united to the heads

* Journ. Exped. Discovery Central Australia, &c., 1845, II. t. 6, f. 4.

† *Ibid.* f. 5.

‡ Aborigines of Victoria, 1878, I. p. 308, f. 85.

§ Voyage of the "Rattlesnake," 1852, II. p. 147.

‖ Proc. R. Irish Acad., 1888, I. (3), No. 1, p. 64.

¶ Proc. R. Irish Acad., 1888, I. (3), No. 1, p. 65.

either by means of gum-cement alone, or the heads are fitted into the hollow ends of the reeds and then plastered over, being either plain or variously ornamented with pipeclay. One of these spears, termed *Maleagemmah-ojalie*, consists of a sapling shaft, with white spiral lines on the head and three white rings at each end. The length of the shaft is six feet ten inches, that of the head two feet nine inches, the total length therefore being nine feet seven inches.

The four other spears of this group have reed shafts, and seem to be known simply as *Maleagemmah*. The proximal and distal ends of the shaft in one instance are tipped with pipeclay, the latter extending on to the base of the hardwood head. Another has the proximal end of the shaft lashed with twine and cupped for the womerah-peg, whilst a third is simply covered with gum. The gum-cement may be ruddled, like the shafts, smeared with pipeclay, or of its original colour, black. The heavier of these spears measures—shaft, seven feet two inches; head, one foot eleven inches; total, nine feet one inch;—whilst the lighter is as follows—shaft, five feet; head, two feet one inch; total seven feet one inch.

According to Eyre, the *Maleagemmah-ojalie* is called *Kiko*,* and the *Maleagemmah* is termed *Karkuroo*,† but he is indefinite as to locality. The reed spear of the Victorian Aborigines to a great extent resembles that of the north coast. Smyth states that by the Goulburn Blacks it was called *Tir-rer*, *Da-aar*, *Djer-rer*, or *Jar-aor*, the reed being *Phragmites communis*, but other names are given to the same weapon on the River Murray. The union between the shaft and head is effected by means of kangaroo sinews and gum-cement.‡

Generally similar to the *Maleagemmah*, but smaller, is a small series spoken of by Mr. Stockdale as "Goose-spears," the largest only measuring five feet six inches, shaft and head (shaft four feet, head one foot six inches). The spears differ from one another only in total length, and relative length of shaft and head. The latter, of hardwood, are round and very sharply pointed. Twine and gum-cement whitened are placed at both ends of the shafts, and in one specimen the nodes of the reed-shaft are transversely banded with pipeclay. The proximal ends are cupped.

This spear is thrown with the *Billetta* womerah, and through the courtesy of Mr. Stockdale, Mr. Hedley and myself had an opportunity of witnessing, by his black servant, the method of throwing, and the astonishing results of this combination of weapons. In throwing, an inclination is given about equal to that of an arrow leaving a bow. It was cast one hundred yards with the greatest ease, and had space allowed evidently might have been propelled much further. The accuracy of aim

* Journ. Exped. Discovery Central Australia, &c., 1845, II. t. 2, f. 8.

† *Ibid.* f. 3 and 4.

‡ Aborigines of Victoria, 1878, I. p. 305.

was very precise, the spear being sent midway between Mr. Hedley and myself, as requested it might be. Even the force of propulsion was equally marked, the head of the spear penetrating quite four inches into the crown of a metalled road, and requiring the strength of both hands to withdraw it. Touching the appellation of these spears—"Goose-spears": they seem to be well named, for Leichhardt in the account of his journey from Moreton Bay to Port Essington refers to the immense numbers of geese seen on the upper East Alligator or Goose River.*

The next type is strictly a fighting spear, *Yoko-ojale*, (Pl. xxx. fig. 1), spoken of commonly by Mr. Stockdale as "Lace-spears." The shafts are saplings, ruddled, about six feet six inches long, cupped at the proximal end for the reception of the womerah-tooth, but not covered with gum-cement or whipped with twine. The hardwood heads are one foot six inches long, rounded on the back, or non-serrate face, the sides flattened, and bevelled off to a sharp edge on the front; the flattened surfaces perforated by a series of oblique ovate holes, the five proximal ones directed upwards, the remainder downwardly so. The heads are attached to the shafts with gum-cement, first ruddled, and the mesh-work picked out with white and yellow, and the rounded backs ornamented with white checker-work in a diamond pattern. Immediately above the gum-cement, and at two other points, are transverse bands of red and yellow.

A modification of this spear exists in so far that the ovate mesh-work of the head is bilaterally symmetrical (Pl. xxx. fig. 2). The middle line of the head is slightly convex or ridge-shaped, white checkered, each median ridge having a white line down it. The number of ovate meshes is also increased to twenty-three, but, as in the case of previous spears, the five proximal holes are directed upwards, and the remainder downwards. I have not succeeded in finding any reference to similar spears in the various works consulted.

We now come to a large series of barbed spears, in which the barbs are cut out of one side of the head only and wide apart. The shafts are of reed, ruddled, and in some instances with the proximal ends and nodes of the reeds picked out with pipe-clay. The gum-cement, with which the hardwood heads are affixed, is frequently diagonally streaked with the same material. The sharp barbs are as much as three inches long, with deflected points, and vary from two and a-half to four inches apart.

A second type of single barbed spear has the general characters of the last, but the barbs are stronger and shorter, only one inch long, and much closer together, being only one and a-half inches apart.

* Journ. R. Geogr. Soc., 1846, XVI. p. 235.

Eyre gives a good figure* of this form of spear in general, and terms it simply "war spear of the North Coast," with a total length of nine and a-half feet, the barbed head being three feet. Somewhat analogous spears are figured by Smyth† under the name of *Nandum*, but he does not definitely localise them. He, however, remarks that "great skill, patience, and care are necessary so as to fashion the barbs of the *Nandum* neatly and to keep them whole."

The largest of these spears in the collection is nine feet six inches long and the head two feet six inches more.

A third form again possesses the general features of the preceding weapons, with wide apart barbs, but the backs of the heads are flat, notched down each edge (Pl. XXXI. fig. 1), and whitened with pipeclay. The gum-cement hafting bears spirally arranged lines.

The spears barbed on one side of the head only are naturally followed by those in which both sides are similarly toothed, in other words, bilaterally symmetrical. The shafts are of reed, ruddled or uncoloured, and the nodes sometimes whitened with pipeclay. The gum-cement may be simply black, its natural colour, black with diagonal white lines, wholly white, or red with successive white circles. There are four types :—

1. Head very short and strong, with stout barbs. Shaft eight feet three inches; head eleven inches.
2. Head similar, with the six central pairs of barbs far apart, but the proximal and distal barbs close together, and more in the form of gigantic serrations (Pl. XXXI. fig. 2). The central barbs are slightly curved, the others standing out horizontally, the proximal being more regularly formed than the distal or apical.
3. Head long, with long recurved and far apart barbs, but the distance varying in individual spears. The distal barbs are truncate, with an apical lanceolate barb (Pl. XXXI. fig. 3). Shaft seven feet six inches; head two feet three inches.
4. Similar to No. 3, but the distal three inches of the head with serrations, instead of barbs, the latter themselves very far apart, much recurved and sub-pointed (Pl. XXXI. fig. 4).

The central barbs of Pl. XXXI. fig. 2, No. 2 type, and all those of Pl. XXXI. fig. 3, No. 3 type, are after the pattern of a spear figured‡ by Smyth, without locality, but

* Journ. Exped. Discovery Central Australia, 1845, II. t. 6, f. 1.
† Aborigines of Victoria, 1878, I. p. 305, f. 71-74.
‡ Aborigines of Victoria, 1878, I. p. 304, f. 70.

with the remark "not common." It is, however, not a reed spear, but entirely of wood.

Eyre gives a figure* in which the arrangement of the barbs resembles our Pl. XXXI. fig. 4, but it lacks the terminal serrations. Allowing for the absence of the serrated apex, Pl. XXXI. fig. 4 is not unlike a so-called variety of the *Mongile* spear of the Victorians, given by Smyth,† in the form and distance apart of the barbs. The latter is, however, entirely a wooden spear.

The last example of the double-barbed spear (Pl. XXX. fig. 3), is angular in the middle line of the head, and the barbs graduate in size upwards, being semi-blunt and slightly curved. The shaft is a sapling, six feet six inches long, and pointed proximally, therefore a hand-spear; the head is of hardwood, three feet six inches long. It is not difficult to conceive how this form might have been derived from the double "Lace spear." The form of serration is not unlike that of one of the single *Nandum* spears figured by Smyth.‡

Touching the Port Essington spears generally, used for hunting and fighting, and eliminating the fishing spears, Macgillivray says§ they are of two categories:—

1. Those thrown with the hand alone, are entirely of wood, and usually made of a Eucalypt termed *Wallăru.*
2. Those thrown with the womerah, are shafted with reed and headed with wood barbed in various ways. The wooden-headed spears are thrown with a large flat supple womerah [our *Orro-korr-ok*]; whilst the stone-headed are projected with a stiff flat womerah [our *Billetta*, or *Gnalealing*].

It will be observed that this statement regarding the stone-headed spears hardly coincides with the information supplied by Mr. Stockdale that the latter are thrown with the *Orro-korr-ok.*

The last of the fighting spear series is a double-pronged one. The shaft is a grained bamboo, ruddled, seven feet six inches long, whipped with twine proximally and cupped. The distal end of the shaft is whitened with pipeclay below the gum-cement, with twine holding the head in position, the cement bearing four oblique white lines. The bi-pronged head is one foot eight inches long, the prongs uniserrate, the barbs being short and blunt, and those of each prong looking in contrary directions. One of these bi-pronged spears is figured by Eyre‖ as from the

* Journ. Exped. Discovery Central Australia, 1845, II. t. 2, f. 11.

† Aborigines of Victoria, 1878, I. p. 304, f. 69.

‡ Aborigines of Victoria, 1878, I. p. 305, f. 71.

§ Voyage "Rattlesnake," 1852, II. p. 147.

‖ Journ. Exped. Discovery Central Australia, 1845, II. t. 6, f. 3.

"North Coast," the barbed head being eighteen inches in length. Smyth* likewise records it from Port Essington, where he says it is called *Pillara*, and also mentions its use four hundred miles north of Perth, West Australia. With the exception of the *All-eitch*, or stone-headed spear, this is probably about the ugliest weapon, in the shape of a spear, used in this part of the Continent. According to Hardman,† however, the true *Pillara*, which is confined to the Murchison and Gaskoyne Districts, "is a wooden spear of a formidable nature. The head is about two feet long, of triangular shape, like a bayonet, but on each edge has been carved a series of barbs, pointing backwards." As Mr. Hardman travelled extensively in West Australia, I think we must accept his definition of the *Pillara* spear before that of Mr. Smyth.

Fish spears are represented by one type (Pl. XXXI. fig. 5), treble-pronged as usual. The shaft in this case is also a reed, ruddled, whipped proximally with twine, and the hardwood prongs held in position by the latter and gum-cement, whitened with pipeclay. The prongs are rounded on the back, and set in a triangle, so as to follow one another consecutively. The barbs are large proximally, lessening in size upwards, wide apart, and recurved. The shaft is seven feet four inches long, and the head one foot eight inches. Both Knight‡ and Eyre§ illustrate this spear, the latter calling it the "fish spear of the North Coast," with a shaft eight and three-quarter feet long. It differs essentially from *Gowdalie*,‖ the fishing spear of the Murray River, which consists of three plain diverging prongs, sharpened to an acute point. It is fifteen feet long. Our implement is certainly more akin to a four-pronged spear used for a like purpose in West Australia,¶ or at any rate supposed to be in use there, for Smyth throws some doubt on the matter by suggesting that his example may have come from Port Darwin! The barbed nature of the prongs favours this view.

WOMERAHS.

I have lately described the northern womerahs in so much detail that very little remains to be said. There are three types present in the collection.

The first is the important *Orro-korr-ok* or sabre-like womerah.** Two are nearly straight, but a third is much more curved, indicating therefore a form of variation which has to be looked for in examining these weapons. The largest, three

* Aborigines of Victoria, 1878, I. p. 337, f. 144.

† Proc. R. Irish Acad., 1888, I. (3), No. 1, p. 65.

‡ Ann. Report Smithsonian Inst. for 1879 [1880], p. 266, f. 94.

§ Journ. Exped. Discovery Central Australia, 1845, II. t. 6. f. 2.

‖ Aborigines of Victoria, 1878, I. p. 306, f. 79.

¶ Aborigines of Victoria, 1878, I. p. 338, f. 145.

** P.L.S.N.S.W., 1892, VII. (2), Pt. 1, p. 170, t. 3.

feet eight inches long, in addition to the fine carving of the handle, is ornamented with pipeclay diamond-work and transverse bars. The distal end has transverse white lines, divided by a longitudinal space. The smallest *Orro-korr-ok* is not carved at the proximal end.

The *Billetta* or *Gnalealing** is represented by four specimens, the longest three feet six inches. I find Dr. R. W. Coppinger figures† this weapon from N.W. Australia. Two modifications are shown by him, differing in the size of the emarginated hand-hold and degree of taper of the blade, and in consequence its width.

The third form may, for the want of a better name, be termed the "rod womerah." They consist of portions of very simple and rough saplings, the longest being three feet five, and ruddled. One is provided with a wooden peg, inserted into a kind of gum-cement cap, and then lashed on with twine (Pl. XXXIV. fig. 1). The other peg is of gum-cement only, rather pyriform in shape, whitened with pipeclay. Smyth figures‡ even a more rudimentary rod womerah than either of the foregoing, but without locality.

BOOMERANGS.

The boomerangs sent to the Exhibition do not, strictly speaking, belong to the suite representing the Alligator River Tribe, but are from another living further south-east and on the tableland. The men of the Alligator River Tribe are "spear-men," and not "boomerang-men" as well. Stress was carefully laid on this point by Mr. Stockdale when giving me some particulars of the objects now under description. It is supported by the experience of the late G. W. Earl,§ so well known from his travels in the East Indian Archipelago, who observed that a tribe visiting Port Essington were provided with spears, throwing-sticks, and two-handed clubs, but no boomerangs. Four different types of boomerang were obtained by Mr. Stockdale.

The first type seems to answer to the *Barn-geet*,‖ or war boomerang of the southern tribes. One form of this type are plain unornamented weapons of a light-coloured wood, and possess but little curvature. One measured gave the following results: Length round the curve, two feet eight inches; average breadth, two and a-quarter inches; thickness, about three-eighths of an inch; and weight, twelve ounces.

* P.L.S.N.S.W., 1893, VII. (2), Pt. 3, p. 399, t. 11.
† Voyage of the "Alert," 1883, p. 34, pl. f. 9 & 11.
‡ Aborigines of Victoria, 1878, I. p. 309, f. 93.
§ Journ. R. Geogr. Soc. 1846, XVI. p. 247.
‖ Aborigines of Victoria, 1878, I. p. 313. f. 96.

Another weapon of similar form is ruddled and longitudinally grooved, and at one end is cross-hatched.

An interesting form of this type is represented by several examples made from a dark wood, in which the ends terminate in a central mucro, with emarginations on each side. One face, probably the obverse, is highly ornate and slightly convex; the reverse being flat and longitudinally grooved. The carving in one case consists of a median line of elongately-oval figures, interrupted at the centre of the weapon by a broad transverse bar, with a narrower bar at each end. The convex and concave edges bear a festoon pattern, the festoons longitudinally grooved, and not necessarily facing one another on opposite sides. The synclines of the festoon outline are each distinguished by two transverse notches or nicks (Pl. XXXII. fig. 1). These weapons have a general measurement of two feet and half an inch long, two inches wide, and weigh ten ounces.

Another single weapon is similar to the last in every respect except the sculpture. The median line of oval figures is replaced by two such, dividing the surface into three parts, a broad central band and two lateral zones. The latter exhibit alternate V-shaped and irregular half-circles on one half the boomerang, replaced by semi-ovals on the other, all cross-hatched (Pl. XXXII. fig. 2). There is, however, no transverse central band. Length, two feet one and a-half inches; breadth, two and a-quarter inches; and weight, ten ounces.

A third form is identical with the last, only in this case a median transverse band occurs (Pl. XXXII. fig. 3). The side sculpture consists of half-diamond figures, with two V-shaped marks on each re-entering angle.

In the fourth and last boomerang of this type, the central surface is occupied by a four-line band returned again and again upon itself, forming a series of loops. The margins bear alternate large and small cross-hatched squares. The weight of this weapon is eleven ounces.

A rather similarly sculptured boomerang to Pl. XXXII. figs. 1-3 is figured by Lumholtz* from Central Queensland, in so far that the weapon is medianly and transversely divided by an incised bar, one half the surface bearing two rows of consecutive ovals, and the other half three. The margins are sculptured with triangular festoons as before, but the ends of the weapon are not mucronate.

These highly ornamented boomerangs seem to be eminently typical of North Australia, and so differing from those of the southern part, a fact which has not

* Amongst Cannibals, 1890, p. 51, f. *b*.

escaped that painstaking author, the late R. B. Smyth, who figures* a portion of one with four lines of loops like our fourth example above.

The second type of boomerang resembles the *Wonguim*,† or "come-back boomerang," of the southern portion of the Continent, but it is difficult to say much about them without an actual trial. They are slightly plano-convex, uncoloured, devoid of sculpture, and have much the appearance of the above weapon, but are longer. The largest is two feet five inches long, two and a half inches wide, and weighs six ounces.

The third and last type is that of the West Australian *Kylie*.‡ These are very roughly made weapons, apparently adapted roots of a light-coloured timber, rather than wholly shaped out by the hand of the operator. They possess a peculiarly abrupt and sharp curvature. One is perfectly plain, but the other is ornamented by a zig-zag figure like a snake. One half the convex side is covered with bi-undulating lines. Length, two feet; breadth, two inches; and weight, six ounces (Pl. XXXII. figs. 5 and 6).

A very close representation of the second of these weapons is given by Eyre,§ even to the figure of the snake. He terms it the *Wāngu* or *Wangno*, but no special reference to the locality is made. The resemblance to the figure of the *Kylie* given by Smyth is very marked, especially in the double curve.

SWORDS.

The Aboriginal weapon termed a "sword" is a heavy wooden instrument used at close quarters in single combat. An illustration of a duel with swords will be found in Lumholtz's work.‖ By different authors they are said to be both single and double-handed, and from their weight and general want of balance they are not weapons likely to commend themselves readily to the good opinion of the White-man. They are neither used for thrusting nor striking, I believe, at any rate not the heavier kinds, but are swung at an opponent, who protects himself with a shield. It is nothing uncommon to see examples of the northern shields of a certain type with large pieces notched out of the margins with these swords. They seem to vary chiefly as regards size, width, amount of curvature, and ornament.

In the Alligator River Tribe the sword is known as *Meyarrol*. The collection contains two varieties of the same type, a narrowly paddle-shaped weapon, lessening

* Aborigines of Victoria, 1878, I. p. 329, f. 112.

† Aborigines of Victoria, 1878, I. p. 315, f. 99*f*.

‡ Aborigines of Victoria, 1878, I. p. 336, f. 140.

§ Journ. Exped. Discovery Central Australia, 1845, II. t. 3, f. 8.

‖ Amongst Cannibals, 1890, p. 125.

in width towards the proximal end, but there again swelling out to afford a hand grasp. The larger of the two is five feet four inches long, four inches across the blade, and two inches across the thinnest part of the handle; weight three pounds four ounces. The handle, covered with gum-cement and whipped with twine, is proximally emarginate. The shaft is decorated (Pl. xxx. fig. 4) with oblongs or squares in black outline, arranged in pairs and cut off from the blade by alternate red and white transverse bands, which are repeated at the centre of the blade and again at the distal end. Each of the intermediate spaces bears a rhomb in red, with a central line, all other parts of the blade being covered with pipeclay checker-work.

In the smaller sword (Pl. XXXIII. fig. 1) the shaft is simply stained indian-red, the cross bands of the blade alternately red and yellow instead of red and white; the intermediate spaces bear a series of imperfect rhombs, divided by a thick red line, and the remainder of the blade as in the first specimen. The twine of the handle is marked with a white cross.

Macgillivray says* that the Port Essington swords, which he terms clubs, are made of a heavy Eucalypt called *Wallăru.* He divides them into three sections:—(*a*) Cylindrical, tapering at each end, and four feet long; (*b*) narrow, compressed, with sharp edges, four feet long; (*c*) similar to (*b*), and like a cricket-bat with a short handle.

The examples now figured possibly fall into the first section. Smyth gives an illustration† of one, describes it as "almost paddle-shaped," and rightly ascribes it to Port Essington. It has the same emarginate proximal end. The shaft is unornamented except the usual red body colour, but on the blade a central longitudinal lenticular space is marked off by two white lines, the lateral spaces by white divaricating lines, and the blade separated from the shaft by two transverse lines of a similar colour.

Eyre's figure‡ of the "two-handed sword" of the North Coast is referable to Section (*c*), but is not a good example of it. It is a lanceolate piece of hardwood, cylindrical, somewhat expanded in the centre, and accuminating distally. The apical fifth bears five equidistant transverse narrow bands.

The sword of the Mackay District§ is to some extent curved like a scimitar, with a narrow handle, ornamented at the distal end with serpentine bands of pipeclay. It is two feet eleven inches in length, again coloured red, and is a double-handed weapon.

* Voyage "Rattlesnake," 1852, II. p. 147.

† Aborigines of Victoria, 1878, I. p. 308. f. 86.

‡ Journ. Exped. Discovery Central Australia, 1845, II. t. 6, f. 6.

§ Smyth, Aborigines of Victoria, 1878, I. p. 303, f. 66.

The sword in use at Rockingham Bay is quite of the type *c*, with a very short handle and a long blade, sharp at both edges, four feet nine inches long, and weighs from eight to ten pounds.*

In the Herbert River District,† says Lumholtz, the sword is curved after the Mackay type, and coloured with white cross-bars. At Port Hinchinbrook, Mr. G. E. Dalrymple‡ saw swords made of a hard and tough wood like brigalow, and curved, with a point like that of an infantry sword. The handle is fined off, and large enough for one hand only. It will be at once apparent from a perusal of these quotations how general the same type of sword is over a large area of Queensland, differing only in detail. Even in Central Australia, about Cooper's Creek, the sword, or something very like it, is in existence; for Howitt refers to a "great boomerang," about five feet long, which is never thrown, but used as a "club or broadsword at close quarters."§ Knight,‖ in his "Study of the Savage Weapons at the Centennial Exhibition, Philadelphia, 1876," figures these swords as Victorian throwing-sticks! The relative proportions of one of these swords and the native using it is well shown in one of the plates of Mr. A. Meston's "Queensland Railway and Tourists' Guide."¶

FIGHTING-STICKS.

Under the name of *Kon-nung*, R. B. Smyth figures a more or less cylindrically pyriform stick pointed at both ends, varying from two feet six inches to three feet in length. "It is employed in close combat principally, and dreadful wounds are inflicted by it sometimes. The warrior, holding it with the right hand by the middle, makes stabs into the neck, breast, and sides of his opponent, and not seldom forces the sharp point into the eye. The stick is also used as a missile."**

Several weapons, of a slightly more pyriform shape than Smyth's figure, are in the collection, made of a dark heavy wood. They are longitudinally grooved, the distal end being rather larger than the proximal, which is cross-hatched. There is a good deal of variation in the length of the distal point beyond the pyriform enlargement. The longest is two feet five and a-half inches, weighing fourteen ounces.

Another form of the *Kon-nung* of the Alligator River Tribe (Pl. xxx. fig. 5) resembles the last, except that it is quite smooth, blunt proximally, and provided

* Aborigines of Victoria, 1878, I. p. 303, f. 67.

† Amongst Cannibals, 1890, p. 332.

‡ Journ. R. Geogr. Soc., 1865, XXXV., p. 205.

§ Smyth's Aborigines of Victoria, 1878, II. p. 304.

‖ Ann. Report Smithsonian Inst. for 1879 [1880], p. 227, f. 28.

¶ Queensland Railway and Tourists' Guide, p. 144, pl.

** Aborigines of Victoria, 1878, I. p. 302, f. 64.

with an incised band on the pyriform enlargement. It is one foot nine inches in length. Lumholtz figures* a *Kon-nung* similar to this weapon, but pointed at both ends, from near Rockhampton. Strictly speaking, these are not *Nulla-nullas*, although frequently called so. This term is one in use on the Lower Murray, for a weapon made from a small sapling, with the root fashioned into a formidable knob, and answers very much better to what we term a bludgeon.

CLUBS.

The *Mattina*† of the Mackay District is a most formidable club-shaped weapon, bearing at the distal end a coronet of wooden nail-like projections.‡ I apply this name, for the want of knowing that given by the Alligator River Blacks, to similar offensive weapons used by them. In one instance (Pl. xxx. fig. 6), the coronet consists of twelve rows of projections, eight in a row, the stick itself being stained black and pointed at both ends. The proximal end is grooved. The length of this instrument is two feet three and a-half inches, and the weight one pound five ounces.

In another specimen, the coronet consists of sixteen rows, five projections in a row, and whitened, the remainder coloured red. It is two feet three and a-half inches long, and weighs one pound five ounces.

A perfectly similar weapon in use on the Burdekin River, is figured by Smyth, and was also seen at Herbert Vale, Central Queensland, by Lumholtz.§ There is also a curious general resemblance between the *Mattina* and clubs used in the Portuguese Colonies of the Mozambique.||

SHIELD.

The only shield in the collection is after the type of the *Goolmarry*¶ of the Mackay District, but quite unlike the large irregularly oval light shields of Eastern Central Queensland. The present example is elliptical in shape, two feet one inch long, and seven and a-quarter inches wide, weighing two pounds four ounces. The apices, both on the outer and inner sides, are stripped of the outer woody layer, exposing the grain. On the convex outside there is a longitudinal median incised

* Amongst Cannibals, 1890, p. 73, f. *a*

† Smyth, Aborigines of Victoria, 1878, I. p. 300, f. 59.

‡ The practice of adapting articles of civilized manufacture by the Blacks is well exemplified in the case of some of these clubs in the Ethnological Gallery of the Australian Museum. Instead of the projections being carved out of the wood, as in the present case, they are made by inserting horse-shoe nails.

§ Amongst Cannibals, 1890, p. 73, f. *b*.

|| Knight, Ann. Report Smithsonian Inst. for 1879 [1880], p. 217, f. 2.

¶ Aborigines of Victoria, 1878, p. 334, f. 138.

line, coloured red, and along each margin are five semi-circular incised spaces. The inside is flat, with a deltoidal incised space on each side, above and below the hand cavity (Pl. XXXIII. figs. 2-4). Although similar in shape and decorticated apices, the Mackay shield is more elaborately ornamented both inside and out.

Hardman* has remarked upon the rarity of meeting with shields ornamented inside. He states that the *Carrbina* of the Kimberley Black is so; here we have two other cases in point, the Mackay shield and the present one from Port Essington.

LUBRA FIGHTING-STICK.

The native women, it is well known, are given to fighting with long stout sticks, sharpened at both ends. The method adopted has been well described by Smyth† and illustrated by Lumholtz.‡ The same stick is also used for digging roots, and is generally termed a "yam-stick"; it is frequently as much as seven feet long.

A stout heavy stick, weighing two pounds fourteen ounces, and obtuse at the ends, is represented by one specimen. It is made from a hardwood sapling, four feet six inches long and one and a-half inches in diameter, but is not pointed at either end. I am not absolutely certain that it should be included under this heading on that account.

II.—IMPLEMENTS, PERSONAL ORNAMENTS, AND MANUFACTURES.

TRUMPETS.

Three very curious trumpets, often used in the corroboree, and differing from one another chiefly in ornamentation, are not the least interesting objects of the collection, and I regret that I have been able to learn so little about them. They are made from bamboo lengths, the diaphragms having been removed, probably by dropping live coals down the tubes. The bamboo, I am informed by Mr. Stockdale, grows about the Adelaide River, over an area of about one hundred miles by fifty, and reaches to a height of eighty feet. Mr. J. H. Maiden tells me there are two bamboos indigenous in Australia, *Bambusa arnhemica*§ and *B. moreheadiana*, the latter a climbing species and only one or two inches in diameter. Judging by the

* Proc. R. Irish Acad., 1888, I. (3), Pt. 1, p. 67, t. 2, f. 3.

† Aborigines of Victoria, 1878, I. p. 351.

‡ Amongst Cannibals, 1890, p. 124, pl.

§ See Australian Journ. Pharmacy, 1886, I. (n.s.), p. 447 (*fide* Maiden).

size, therefore, the trumpets are probably made of *B. arnhemica.** They are all about the same length and appear to be very difficult for the uninitiated to blow, but from the notes Mr. Stockdale was able to produce, must be very sonorous. The noise is very like that given forth by the South Sea Island Conch (*Triton nodiferus*, Linn.).

The longest tube, three feet three inches, is straight (Pl. xxx. fig. 7), with the nodes of the bamboo picked out in red, the proximal end coloured red, white and blue, in a more or less diagonal pattern. The internodes are covered with incised checker-work.

The tube intermediate in length (three feet one inch) between the last and the smallest is slightly curved. The proximal twelve inches is covered with what appears to be white-lead paint, thence upwards many of the internodes are elaborately carved, chiefly with incised checker-work arranged in rings, squares, or oblong spaces. Near the distal end one internode is nearly covered by vertical zig-zag lines.

The smallest tube (Pl. XXXI. fig. 6) is also curved, and much more highly carved than either of the preceding. Near the centre is an internode with a zig-zag pattern, and on some of the others are designs of a peculiar and indefinite character. This tube is three feet long.

Dr. Coppinger† saw in a camp of the Larikia Tribe at Port Darwin the natives "producing a rude burlesque of music out of pieces of hollow reed, about four feet long, which they blew like cow-horns." This is the only reference I have been able to find referring even probably to the use of these instruments.

BELTS.

The belts used by the Alligator Tribe are highly ornate at the outer ends, and to a certain extent remind us of those used by the natives of some parts of New Guinea. Those now under notice are of ribbon-like wood, rigid, but at the same time easily bent in the direction of the grain, from five to nearly eight feet long, and elaborately coloured at the outer or exposed end.

The largest is seven feet nine inches long, four inches wide, and weighs one pound four ounces. The coloured portion extends over a space of two feet seven inches, and the pattern consists of red and white lines in various curves and white checker-work, the white colours, as in nearly all these objects, being pipeclay

* Mr. Maiden has subsequently informed me that this tree grows to a height of from 30 to 50 feet, and four inches is a common diameter. It is found along the coast from Port Darwin, and probably extends to the Alligator Rivers.

† Voyage of the "Alert," 1883, p. 204.

(Pl. xxxiv. fig. 2). This belt and the two following seem to be made of an easily split wood.

The next longest is seven feet, three and a quarter inches wide, and ten ounces in weight. The largest belt maintains the same width throughout, but in this case a certain amount of taper is apparent. The pattern colours used are red, white, blue and yellow (Pl. xxxiv. fig. 3), and the pattern too complicated for description.

The third example is much shorter, only five feet six inches long, three inches wide, and eight ounces in weight. The pattern consists of more or less triangular spaces, transverse bands and white checker-work (Pl. xxxiv. fig. 4).

I know of but very few references to these belts. Inspector Paul Foelsche is one of the few who speaks* of the "painted belts made of bark used by the natives of North Australia."

The general character is that of the belts figured by Dr. O. Finsch† from Maiva and Kerrema in New Guinea. He terms them *Goaioa,* and says that they are made of a thin hard bark. They are painted red, or covered with a plaiting of finely split bamboo, the outer ends are then figured with much more elaborate and artistic drawings than those on the North Australian, and filled in with white and red colour. Mr. E. G. Edelfelt also mentions the wearing of an elaborately carved and painted bark belt.‡

Another form of belt is that made of human hair, chiefly female I believe, twisted into twine, of which there are several hanks in this collection ready for use.

In the Dieyerie Tribe of the south, the male hair belt, called *Yinka,* is three hundred yards in length and greatly prized from the difficulty in procuring it.§ Howitt also noticed that the Cooper's Creek men had "a very long cord wound round and round the waist like a belt."‖ And Foelsche directly refers to the wearing of female hair round the waist in North Australia, but amongst the Kimberley natives the hair girdle is only worn by the piccaninies.¶ Human hair was also worn by the men of the Port Lincoln Tribe, South Australia, the hair spun into a yarn, and the latter twisted into a girdle,** but strangest of all is Oldfield's statement†† that

* Trans. R. Soc. S. Australia for 1881-82 [1882], V. p. 14.

† Ueber Bekleidung, Schmuck, und Tätowirrung der Papuas der Südost Küste von Neu-Guinea. *Mith. Anthrop. Gesellsch. Wien,* 1885, XV. pp. 3 & 4 (sep. copy).

‡ Trans. R. Geogr. Soc. Austr. (Queensland Branch), 1892, VII. Pt. 1, p. 21.

§ Gason in Smyth, Aborigines of Victoria, 1878, I. 281.

‖ Smyth's Aborigines of Victoria, 1878, II. p. 302.

¶ Froggatt, Proc. Linn. Soc. N.S. Wales, 1888, III. (2), p. 652.

** Schürmann, Aboriginal Tribes of Port Lincoln in South Australia, 1846, p. 2.

†† Trans. Eth. Soc., 1865, III. (n.s.), p. 268.

the women of the Shark's Bay Tribe, West Australia, were *annually shorn* for the purpose of making hair-twine. The custom, therefore, of using human hair as a belt or girdle material appears to have been a common one throughout the Continent.

ARMLETS.

The armlets are made of two materials, grass and string, and are of various breadths. Those of grass or straw consist of a series of rings, each of equal size, lashed together, or they may be made of plaited straw. The string armlets, on the contrary, are longitudinally plaited and either stained red or whitened. Those made of straw are three inches in diameter and two and a quarter inches wide; those of string, three and a half inches diameter and two inches in width.

Inspector Foelsche speaks* of rings of grass being worn by the North Australian tribes "plaited round the arms above the elbow, round the wrists and fingers." In other parts of Australia, Gippsland for instance, such armlets as these were replaced by strips of Flying-squirrel skin or that of the Ring-tailed Opossum.†

NECKLACES.

One form of necklet worn by this tribe, and apparently an ornament widely distributed over Australia, is made of straw stalks cut into beads or bugles of various sizes strung on twine of varying degrees of thickness.‡ These were worn both by men (Pl. xxxv. fig. 2) and women. Smyth says§ that a necklace such as this, measured by himself, was thirty feet or more in length, and one contained four hundred and seventy-eight pieces. Reed necklaces were worn both by the Yarra and Gippsland Tribes of Victoria, the former calling it *Kor-boort.*

Inspector Foelsche refers to the use of these necklets by the North Australian. He says‖ "Necklets made of grass stems cut in half-inch lengths, representing beads, are put on strings and worn round the neck." Their use at corroborees in Victoria is mentioned by Stanbridge,¶ the necklaces consisting of a great many coils of short pieces of threaded reed.

A second necklet consists of twenty-two kangaroo incisors strung on string (Pl. XXXIV. fig. 5). The base of each tooth is coated with gum-cement and coloured

* Trans. R. Soc. S. Australia for 1881-82 [1882], V. p 14.

† Aborigines of Victoria, 1878, I. pp. 271, 275.

‡ Lumholtz states that in the Herbert River District a necklace of yellow grass bugles, strung on string long enough to go round the neck ten or twelve times is worn as an "emblem of mourning." Amongst Cannibals, 1890, p. 203.

§ Aborigines of Victoria, 1878, I. p. 279.

‖ Trans. R. Soc. S. Australia for 1881-82 [1882], V. p. 14.

¶ Trans. Eth. Soc., 1861, p. 297.

red. The string is passed through the gum, then round each tooth and knotted. In another necklet made of similar teeth (Pl. XXXIV. fig. 6), the latter are smaller, and the string is simply passed through a hole in the gum-cement and not tied.

In other instances, the teeth, instead of being strung, are tied in a bunch and attached to a cord with an eye, through which its own part runs to form a loop. Eyre figures* such an ornament; or the teeth may be attached to a strip of kangaroo skin.†

FILLETS AND HEAD ORNAMENTS.

Forehead bands or fillets appear to have been very extensively worn throughout the whole of Australia.

A fillet of the Alligator Tribe is made of string woven, the longest threads being left free at the ends and gathered together in knots. It is stained red, the outer side coated white, leaving two median transverse red bands and one at each end. Smyth speaks‡ of the fillet worn on the Bulloo Downs, Queensland, being covered with pipe-clay. On the Lower Murray this portion of dress is known as *Mar-rung-nul.*

Another fillet consists of opossum hair twisted into a kind of loose twine, strung together, tied at opposite ends, and there whipped round. It is stained red. This form of head band is common throughout Australia. Eyre figures§ one from the North Coast.

What is probably a head ornament consists of White Cockatoo feathers mounted as a tuft in gum-cement at the end of a number of strings of twisted opossum hair. The manner of wearing such tufts is shown in our Pl. XXXV. fig. 1. In the Adelaide Museum a figure of a native is shown decorated with one of these tufts in a different manner. The string is placed round the man's neck, the tuft of feathers hanging in the middle of his back. A somewhat similar but very much larger ornament is figured by Eyre.||

A further utilisation of birds' feathers is shown in a fine plume of the wing feathers of the "Magpie Goose," bound together by whipping the shafts with twine and covering with gum-cement. Another plume consists of similar feathers of the Native Companion united in the same way. A third plume is made by mounting the feathers of the Emu at the end of a small piece of bamboo or reed, with gum-cement. In our Pl. XXXV. the method of wearing these head ornaments is shown, but Mr. Zietz,

* Journ. Exped. Discovery Central Australia, 1845, t. 6, f. 11.
† Aborigines of Victoria, 1878, I. p. 278, f. 27.
‡ Aborigines of Victoria, 1878, I. p. 276.
§ Journ. Exped. Discovery Central Australia, 1845, t. 6, f. 17.
|| Journ. Exped. Discovery Central Australia, 1845, t. 6, f. 10.

the energetic Curator of the Adelaide Museum, pointed out to me a plume of White Cockatoo feathers mounted in a precisely similar way, forming the apical ornament of a very remarkable Corroboree pole, and again in a similar position on the equally peculiar masks worn in the Corroboree at Port Darwin. Lumholtz states* that on the Herbert River, tufts of Talegalla feathers are held in the mouths of the dancers, whilst further corroborative evidence of the use of these tufts is given by Foelsche, who says† that "bunches of white feathers fastened to a short painted stick are stuck in the hair" amongst the North Coast tribes.

APRONS.

The front covering, or apron, worn by males was made in some tribes of strips of skin, in others circlets of string were used. A number of the latter are present in this collection of different degrees of coarseness, whipped at opposite ends to keep them together, some containing as many as fifty rounds or circlets. The twine is coloured either of the usual indian red or ochre, whilst the whipping is green or white. The male figure, previously referred to in the South Australian Museum, has similar bundles of twine suspended in front from the girdle and acting practically as an apron.

In southern tribes using the skin strips, these when made of opossum skin are called *Barran-jeep*.‡

BODY-CORDS.

Long lengths of twine, of different sizes, are stained indian red and formed into two loops and used as body decorations. The arms are passed through the loops, so that the line of union of the two rests vertically along the back between the shoulder blades, the front portion of the loops giving support to the pectoral muscles and mammæ. The united portion is whipped with its own material.

Mr. J. F. Mann describes§ a peculiar modification of these body-cords, made in this instance of spun opossum hair. It is first placed round the loins, then alternately over each shoulder, and finally round the neck, imparting the appearance of both a girdle, necklet and cross belts.

BASKETS.

The baskets are numerous and of various sizes. They are made of small reeds or rushes, and although flexible are particularly tough.

* Amongst Cannibals, 1890, p. 237.

† Trans. R. Soc. S. Australia for 1881-82 [1882], V. p. 14.

‡ Smyth, Aborigines of Victoria, 1878, I. p. 273.

§ Proc. Geogr. Soc. Austr. (N.S. Wales and Vict. Branches) for 1883-84 [1885], I. p. 36.

The largest is beautifully made of close rushwork, with a string handle, and is very much akin to a basket figured by Smyth* from the Burdekin Tribe. It is two feet ten and a half inches long (Pl. XXXIV. fig. 7). The rush or flag appears to have been split into very thin strips, representing the "staking" in ordinary now-a-days basket work. These are held in position by intertwining with them the horizontal bars or "siding." The groundwork of the bag is stained indian red as usual, and relieved by four equidistant encircling narrow bands, which with the apex and portions of the mouth edges are stained a fine orange yellow. On what may be presumed to be the front of the bag the spaces between the orange cross-bands are covered with rectangular or hour-glass shaped figures, five in each zone. Those of the top zone are rectangular and white; in the second zone the two left-hand and the extreme right-hand figures are hour-glass shaped and white, the two intermediate ones being rectangular and black. In the third zone from the mouth, all are hour-glass shaped and white. The figures of the bottom zone are all rectangular and coloured like those of the second tier.

Another basket, rather less in length, but of similar construction, is uncoloured, except at the base or apex, where there are three narrow transverse bands of indian red picked out with pipeclay dots.

A third basket, only nine inches long, and quite similar to the foregoing, is simply stained red without transverse bands of any kind.

All three baskets have string handles, from one end of the mouth only, and their general durability is remarkable. In figuring a very beautifully made basket of this description Lumholtz says they are sometimes ornamented with stripes and dots of blood taken from the maker's own arm.†

Other baskets of a more open meshwork are constructed by forming the "staking" of five untwisted pieces to each upright or stake, with the "siding" in one case consisting of a bi- or tri-twist (Pl. XXXII. fig. 7), or of two or three untwisted strands (Pl. XXXII. fig. 8). These baskets are either uncoloured or covered with scattered red blotches. They vary in size from seven and a-half to nine and a-half inches long.

The principle of manufacture is quite similar to that of a Tasmanian bag figured by Ling Roth,‡ consisting of a "series of upright pieces of reed held partially in position by means of two pieces of twisted fibre, which two are again twisted into each other in such a manner as to enclose at every twist one of the upright reeds."

* Aborigines of Victoria, 1878, I. p. 346, f. 161, *a* and *b*.

† Amongst Cannibals, 1890, p. 194.

‡ Aborigines of Tasmania, 1890, p. IX. f. 2, and f. 3.

Roth says this is similar to the basket-work made in many other parts of the world, as well as fabric from the Swiss Lake dwellings, and bark mats and bark bags made by the Ainos of Japan.

Of an entirely different character are two strong, well made, open, somewhat oblong baskets with stiff cane handles, more after the fashion of a White-man's basket. They seem to be made of the spathe of some large inflorescence which Mr. Stockdale says is that of the Cabbage Palm. These baskets are termed *Mar-ro-ing*.

Bags.

The bags are entirely made of a coarse, harsh, bi-strand string, and are long, narrow at the mouth, and expanding downwards. The largest bag is uncoloured, and has a rhomboidal mesh, one and a-half inches in longitudinal diameter. The knot used (Pl. xxxii. fig. 9) is as near as possible that known to mariners as the swab-hitch or weavers' knot. Smyth figures* a precisely similar knot used in making a fishing-net from the Burdekin River.

A second bag, of a triangular shape, and stained indian red, is one foot long, with a three-quarter inch rhomboidal mesh, formed in the same way as the last bag.

The third of these large bags is rather pyramidal, the coarse string knitted in diagonal lines by a simple twist without knotting, producing a very close mesh. The mouth is semi-lunate, and beautifully finished off with a string handle, arising from opposite sides. The mesh is formed by simple loops (Pl. xxxii. fig. 10), and is identical with that of a fishing-net figured by Smyth from Lake Tyers, South Gippsland.† It is also similar to a Tasmanian bag in the Oxford Museum, and Roth‡ further points out that the mesh is identical with a stitch used in modern point-lace work, called the "plain net or first lace stitch." The twine consists of fibre "twisted into two strands, which are again twisted together to form the cord."

The remaining bags are small, and are used, so Mr. Stockdale says, for personal adornment—one, for instance, being placed on the breast and another behind each ear, &c. One is oblong, six inches long, and stained a dark umber. It is made of a bi-twisted coarse strong twine, with a rhomboidal mesh, knotted at the angles, each opening of the mesh with a diameter of three-quarters of an inch (Pl. xxxii. fig. 11). Another of these small bags is triangular, and stained indian red. It is six and a-half inches long and four and a-half inches across the base. The twine in this case

* Aborigines of Victoria, 1878, I. p. 390, f. 225.
† Aborigines of Victoria, 1878, I. p. 389, f. 223.
‡ Aborigines of Tasmania, 1890, p. X. f. 3.

is soft, bi-twisted, forming a small rhomboidal mesh, knotted as in the preceding bag at the angles. Two other bags are square, five inches long, with semi-lunate mouths. The mesh is similar to that of Pl. XXXII. fig. 11.

GOURDS.

These are quite unlike the usual rough make-shift utensils usually employed by the Aborigines to carry water in, but resemble the ordinary earthenware water-monkey in use in everyday life, a round body with a long tube-like neck, such as would be produced by the fruit of *Lagenaria vulgaris*. The only published reference I can find to the use of a similar gourd in the north is, strange to say, in one of Coppinger's figures* of the grotto drawings at Clack Island, Torres Straits. The drawing represents a similar gourd, but with a longer neck, and is ornamented with transverse bands that may be either incised lines or pipeclay dots, which Coppinger says most of the objects represented on the walls of the cave are marked with.

EXPLANATION OF THE PLATES.

PLATE XXX.

Fig. 1.—*Yoko-ojale*, or "lace-spear," used in fighting.

Fig. 2.—A bilaterally symmetrical modification of fig. 1.

Fig. 3.—Double-barbed spear, with barbs graduating upwards.

Fig. 4.—*Meyarrol*, or sword, highly ornate.

Fig. 5.—*Kon-nung*, or fighting-stick.

Fig. 6.—*Mattina*, or fighting-club.

Fig. 7.—Corroboree trumpet made of bamboo stem.

PLATE XXXI.

Fig. 1.—Serrated spear-head, with wide apart recurved barbs and a flat notched back.

Fig. 2.—Doubly-serrated spear-head, with three forms of barbs.

Fig. 3.—Doubly-barbed spear-head, with strong barbs far apart and a lanceolate apex.

Fig. 4.—Doubly-barbed spear-head, with recurved barbs far apart and a serrated apex

Fig. 5.—Fish spear-head of three prongs.

Fig. 6.—Corroboree trumpet of curved bamboo.

* Voyage of the "Alert," 1883, p. 192, pl. f. 6.

Plate xxxii.

Figs. 1-3.—Portions of carved boomerangs, with mucronate ends, after the type of the *Barn-geet.*

Fig. 4.—Outline of the entire boomerang to illustrate the full outline.

Fig. 5.—Boomerang after the type of the *Kylie*, with incised bi-undulating lines.

Fig. 6.—Flat side of the same weapon, with an incised figure of a snake, or perhaps a millipede.

Fig. 7.—Basket-work "staking" and "siding."

Fig. 8.—"Staking" and "siding" of another basket.

Fig. 9.—Bag-mesh, opened out to show method of knotting.

Fig. 10.—Bag-mesh formed of simple loops.

Fig. 11.—Bag-mesh, knotted at the angles.

Plate xxxiii.

Fig. 1.—*Meyarrol*, or sword, highly coloured in red, white, and yellow.

Fig. 2.—*Goolmarry*, or shield ; outside view.

Fig. 3.—*Goolmarry*, or shield ; inside view.

Fig. 4.—*Goolmarry*, or shield ; side view.

Plate xxxiv.

Fig. 1.—Proximal end of "rod womerah," showing peg held in position by gum-cement and twine.

Fig. 2.—Outer end of wooden pliable belt, showing coloured ornament.

Fig. 3.—Another similar belt, but shorter.

Fig. 4.—A third still shorter belt.

Fig. 5.—Necklace of kangaroo incisors, held in position by gum-cement, and twine passed round them.

Fig. 6.—Another necklace, with the twine passed through the gum-hafting.

Fig. 7.—Rushwork basket, coloured indian red, and ornamented with black, yellow, and white.

Plate xxxv.

Fig. 1.—Head of Alligator River native, full face, exhibiting use of the nose bone, and tufts of feathers in the hair.

Fig. 2.—Another head, profile, with necklace of grass bugles, head fillet of twine, and bunch of feathers as a forehead ornament.

NEMATODES, MOSTLY AUSTRALIAN AND FIJIAN.

By N. A. COBB.

(Plates XXXVI.-XLII.)

INTRODUCTORY NOTE.

The following pages contain descriptions, accompanied by about one hundred and seventy figures, of eighty-two species of Nematodes, of which about half have not been hitherto described. In a number of cases the anatomical details have been worked out in a manner worthy the attention of the morphologist.

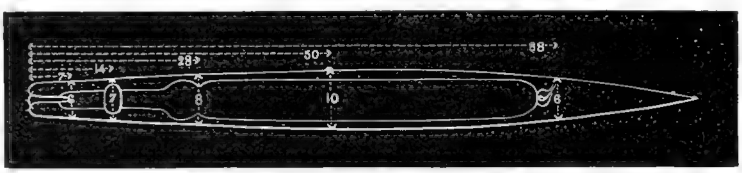


FIG. 1.—Diagram in explanation of the descriptive formula used for Nematode worms; 6, 7, 8, 10, 6 are the transverse measurements, while 7, 14, 28, 50, 88 are the corresponding longitudinal measurements. The formula in this case is:—

$$\frac{7\cdot \quad 14\cdot \quad 28\cdot \quad 50\cdot \quad 88\cdot}{6\cdot \quad 7\cdot \quad 8\cdot \quad 10\cdot \quad 6\cdot}$$

The unit of measurement is the hundredth part of the length of the worm, whatever that may be. The measurements become, therefore, percentages of the length.

The measurements are taken with the animal viewed in profile; the first is taken at the base of the pharynx, the second at the nerve-ring, the third at the cardiac constriction, the fourth at the vulva in females and at the middle (M) in males, the fifth at the anus.

GENUS MONONCHUS, Bastian.

The genus *Mononchus* is composed of herbivorous free-living Nematodes, not marine, having the average formulæ $\frac{2\cdot5 \quad 7\cdot6 \quad 25\cdot \quad \text{‘}60\text{’} \quad 90\cdot}{2\cdot5 \quad 2\cdot8 \quad 3\cdot6 \quad 3\cdot8 \quad 2\cdot}$ 2mm. and $\frac{2\cdot5 \quad 7\cdot6 \quad 25\cdot \quad \text{—M—} \quad 90\cdot}{2\cdot5 \quad 2\cdot8 \quad 3\cdot6 \quad 3\cdot8 \quad 2\cdot}$ 2·(—)mm. They are readily recognised by their capacious pharynx, containing from one to three commonly conspicuous teeth, whose function is, in conjunction with certain minute file-like or rasp-like areas on the wall of the pharynx, to masticate the food, which consists of fresh and succulent vegetable matter, such as rootlets, or the tissues of aquatic or sub-aquatic plants, or the protected tissues found among the sheaths of the leaves of certain land-plants. The thick transparent cuticle of these worms is destitute both of hairs and striæ. The neck is sometimes almost cylindrical, but is usually conoid, and invariably ends in a truncate head, which in one species

(Tunbridgensis) is contracted, but in all the others is slightly expanded at the lip-region. Two rows of tactile organs, each consisting of six conical innervated papillæ, surround the mouth,—the outer spreading row being situated on the margin of the head, while the inner row closely surrounds the mouth. These papillæ are usually of uniform size, but sometimes those of one row, usually the inner, are larger than those of the other. It is tolerably certain that the number of lips is three, and that each lip is two-parted, though this is not an easy thing to demonstrate, owing to the fact that the lips are very low and nearly confluent. The mouth-opening is small, the length of the passage leading from it to the pharynx being determined by the thickness of the lips, which are uncommonly bulky and powerful. Behind the lips the pharynx assumes at once its full width, which is tolerably uniform throughout its length in most species; in a few, however, the posterior part narrows somewhat gradually instead of suddenly. The absolute length of the pharynx varies, speaking roughly, from 30μ to 60μ, the smaller species, as a rule, possessing a smaller pharynx, but not by any means proportionately smaller. *M. digiturus*, for instance, notwithstanding that it is only half as large as *M. longicaudatus*, has a pharynx quite as large as that of the latter. In form the pharynx varies between triquetrous and hexagonal, usually three and sometimes all of its edges being clearly indicated by longitudinal more or less curved chitinous ribs. A dorsal tooth seems always to be present, though it is occasionally inconspicuous. It is usually situated near the middle of the dorsal side of the pharyngeal cavity and projects forward and inward, often so much as to be very conspicuous. A few species possess ventral submedian teeth, rivalling the dorsal in size, and placed on a par with it; probably these submedian teeth exist in a more or less rudimentary condition in most of the species, but have been overlooked and hence left unnoticed by the authors. Portions of the chitinous walls of the pharynx are covered with minute teeth or roughnesses, resembling sometimes those of a rasp (first noticed by Dujardin) and sometimes those of a mill-saw file (first noticed by Bütschli). These rasp-like or file-like roughnesses appear to have a definite relation to the form of the pharynx, and to have a definite function, namely, to aid in mastication. I have observed that the species possessing rasp-like roughnesses have them placed in opposition to the projecting part of the dorsal tooth, the areas covered by the minute teeth beginning near the lateral lines and extending toward the ventral part of the pharynx, where the teeth seem less developed than at the sides; the dorsal surface of the pharynx near the dorsal tooth is quite smooth. The species observed by me possessing plain transverse striations resembling the teeth of a mill-saw file, are species in which the dorsal tooth is rudimentary and situated near the base of the pharynx, the position of the striations, however, being precisely that of the above-described bands of rasp-like teeth; the walls of the pharynx are, moreover, in this case traversed by certain curved transverse ridges of such a complicated nature that even after considerable study of them I can

only assert that they must impart to the wall of the pharynx an irregular sculpturing, doubtless well adapting it for mastication, for which purpose the exterior of the pharynx seems supplied with more abundant and more powerful muscles than in the other species. Doubtless these differences can be made the basis of a division of the genus into two natural subgenera. In those cases where the dorsal tooth is placed in the neighbourhood of the lips, I have observed that the anterior walls of the pharynx, or the internal surface of the lips, are armed with large somewhat tooth-like almost backward-pointing processes, which I judge from their position (I have never seen them act) to be the antagonistics of the dorsal tooth. The lips and walls of the pharynx are always supplied with numerous and powerful muscles, concerning whose action Bütschli remarked that the head was often seen to contract longitudinally.

The œsophagus is very simple, being a tube half to two-thirds as wide as the neck, wider posteriorly than anteriorly, without bulbs of any sort, and separated from the intestine by a distinct but shallow constriction, which is sometimes double owing to the fact that the intestine is joined closely to the cardia for a short distance and then suddenly expands. The intestine is two-thirds to three-fourths as wide as the body and ends in a short and narrow rectum, only about two-thirds as long as the anal body-diameter. The intestine is usually thin-walled and is composed of cells whose granules are arranged so as to give rise to a tessellation, often of such a perfect and beautiful kind as to render these worms a most attractive spectacle. The nerve-ring surrounds the œsophagus squarely near the division between its anterior and middle third; before and behind the ring the usual ganglion cells occur. All the species are eyeless. The lateral fields are well developed, being one-fifth to one-third as wide as the body. The lateral organs have remained until now undiscovered in all the species; I find, however, that in *longicaudatus* they exist opposite the middle of the pharynx in the form of small transverse ellipsoidal openings. The ventral gland, too, has hitherto remained unseen, but in *megalaimus* and *digiturus* a pore exists just behind the nerve-ring, and this pore has every appearance of being the outlet of the ventral gland.

The tail varies in length from one-fiftieth to one-fifth of the length of the animal; when short it is conoid, and when long it is conoid in the anterior part and narrow and cylindroid in the remaining part, being always slightly swollen at the terminus, which is rounded and gives exit to the secretions of the caudal glands, probably always three in number.

In two species (*digiturus* and *gymnolaimus*) the female sexual apparatus is single, in all the others as yet made known it is double, the two parts being symmetrically reflexed, in spite of which fact, however, the projecting vulva is usually situated near the beginning of the posterior third of the body, a position in harmony with the

unusually great length of the œsophagus, which seldom occupies in adults less than one-fourth the length of the body. The eggs are usually ellipsoidal and somewhat longer than the body is wide; they are generally deposited before segmentation begins. The reflexed part of the ovaries is usually short, seldom reaching more than half-way back to the vulva.

The tail end of the male generally resembles that of his mate in form, but differs in the presence of numerous low broad papillæ, of which a ventral row of a dozen or more closely approximated ones are found in front of the anus, while several others are found scattered over the tail. Each of the two equal slender spicula is generally supplied near the middle of the shaft with an additional piece of chitin which doubtless serves to render it less flexible. The accessory piece is double and surrounds the spicula.

While the genus *Mononchus* is one easily recognised and defined, it is one whose affinities have been somewhat misunderstood. It does not stand in such close relationship to *Oncholaimus* as was formerly supposed. The structure of the pharynx which was thought to give it that relationship is now more clearly understood, and is seen to present a superficial rather than a real resemblance to the pharynx of *Oncholaimus*. The structure of the lips is very different in the two genera, those of *Mononchus* being thick, armed with a double row of prominent papillæ and not accompanied by cephalic setæ, while those of *Oncholaimus* are thin, lack at any rate conspicuous papillæ and are always accompanied by setæ. The inner walls of the pharyngeal cavity of *Mononchus* are moreover armed with rasp-like or file-like roughnesses, not seen in *Oncholaimus*. Leaving the pharynx we come to other very striking differences. For instance, no ventral gland has yet been demonstrated in *Mononchus*, although it probably exists, while it is never absent and is usually conspicuous in *Oncholaimus*; then, too, the nerve-ring in the former genus is always considerably in front of the middle of the œsophagus, while in the latter it is near the middle or behind it; again the male copulatory organs of the two genera differ widely from each other, and this brings to mind another difference, namely, the extreme rarity of males in one case and the comparative abundance in the other; *Oncholaimus* is marine, while *Mononchus* lives in soils and on the surface of land plants; the peculiar organ seen in the females of *Oncholaimus* has not been met with in *Mononchus*. These differences and others seem to me to show that only a somewhat remote relationship exists between these two genera.

I am of opinion that the worms belonging to this genus can by no means be termed harmless to vegetation. My opinion is based on data collected during several years and is therefore worthy of the attention of vegetable pathologists.

Mononchus is distributed all over the world. I have myself examined specimens from North America, Europe, tropical Asia, Australia and Fiji. The species do not

so far as I have observed differ widely from one another, though this statement may be qualified by our lack of knowledge concerning the males. They are universally found congregated about the roots of plants or in the axils of their leaves, where they thrive by gnawing at the epidermis and the subjacent cells. There can be no doubt that they sometimes occur in sufficient numbers to do visible injury, as witness the following observations:

The edible part of three bunches of nice-looking celery bought of a Chinaman in Sydney was cut off as far up as it was tender,—nearly to the first leaflets. It was washed by hand in a tin dish in tank water, free from nematodes. The washings gave about 200-300 nematodes as follows.

1. *Mononchus longicaudatus*, Cobb, very abundant;
2. *Rhabditis* sp.? less abundant;
3. *Plectus parietinus*, Bast., in numbers equalling the last;
4. *Diplogaster trichuris*, Cobb, a few;
5. *Mononchus* sp.? few;
6. *Dorylaimus* sp.? two at least.

The leaves were also washed; one nematode, a *Mononchus*, was found.

These observations lead me to believe that the damage these worms are capable of doing to plants, especially young seedlings, is considerable, though there is as yet a dearth of evidence on that point.

KEY.

Female sexual organ single: Cheeks thin, i.e., pharynx one-half as wide as the head; teeth basal—

Armed with three equal teeth........ 1. *digiturus.*
Armed with a single small tooth........ 2. *gymnolaimus.*

Female sexual organs double: Cheeks thick, i.e., pharynx less than one-half as wide as the head; dorsal tooth if present, central.

Length not much above half a millimetre........ 3. *crassiusculus.*
Length at least one millimetre.
Head contracted opposite the pharynx........ 4. *Tunbridgensis.*
Head not so contracted.
Dorsal tooth opposed by two large ventral submedian ones........ 5. *tridentatus.*
Dorsal tooth not opposed by others of any size.
Tail conoid and ventrally arcuate.
Anus at 98 %........ 6. *brachyurus.*

Anus at 96 % to 87 %.

Worm about 1· mm. long.

Pharynx thrice as long as wide....................	7. *parvus.*
Pharynx twice as long as wide....................	8. *cristatus.*
Pharynx about as long as wide.....................	9. *minor.*

Worm about 1·8 mm. long.

Pharynx narrow, twice as long as wide..........	10. *papillatus.*
Pharynx about as wide as long........	11. *muscorum.*
Worm about 3 mm. long	12. *major.*

Tail in the posterior part cylindroid.

Anus at 82 %; pharynx less than three times as wide as long	13. *longicaudatus.*
Anus at 86%; pharynx four times as wide as long.........	14. *truncatus.*
Anus situated at length at not less than 90 %...	15. *macrostoma.* / 16. *fovearum.*

1. **M. digiturus,** n.sp. $\frac{3\cdot3 \quad 8\cdot2 \quad 25\cdot6 \quad \text{`}70^{12} \quad 92\cdot}{2\cdot8 \quad 3\cdot \quad 3\cdot4 \quad 3\cdot4 \quad 2\cdot3}$ 1·4 mm. The truncate head is only very slightly expanded. Each lateral field appears to end in a curve opposite the anterior part of the pharynx, and I surmise that these curves are the lateral organs. The pharynx, which is as long as the head is wide and two-thirds as wide as long, is entered through a vestibule one-fifth as long as the pharynx proper ; three longitudinal chitinous ribs occur at the angles of the internal surface of the pharynx and near their bases are seen three subequal rather rudimentary basal teeth, of nearly equal size, only one-third as long as the cavity. The œsophagus is about three-fifths as wide as the neck, being in the middle somewhat narrower than elsewhere ; it is separated from the intestine by a distinct constriction. The gut is three-fourths as wide as the body and ends in a rectum a trifle longer than the anal body-diameter. A ventral pore occurs just behind the nerve-ring. The tail is arcuate-conoid to the somewhat blunt terminus. This and the next are the only known species in which the female sexual organs are not double and symmetrical, and as usual it is the posterior branch which has disappeared ; the remaining anterior branch is short and reflexed. The vulva is not prominent. Drawings are given on Pl. XXXVI.

This worm was found in small numbers about the roots of banana plants, Fiji, July, 1891. No males were seen.

2. **M. gymnolaimus,** n.sp. $\frac{2\cdot6 \quad 6\cdot8 \quad 23\cdot5 \quad \text{`}67^{15} \quad 86\cdot}{2\cdot2 \quad 2\cdot3 \quad 2\cdot7 \quad 2\cdot5 \quad 1\cdot6}$ 2·94 mm. The neck of this species is cylindroid. The diameter of the inner circle of cephalic papillæ is half that of the outer circle. The vestibule is one-fourth as long as the pharynx proper. Opposite the anterior part of the pharynx, near what appears to be the termination of the lateral fields, occur small transverse elliptical markings, probably representing the lateral organs. The strongly three-ribbed triquetrous pharynx is as long as the head is wide, and one-half as wide as long, and presents a single rudimentary dorsal tooth at the base. The transverse striæ on the wall of the pharynx near the middle are

1μ apart. The intestine is laid close on to the cardia,—thus giving rise to a double constriction in the cardiac region,—and is composed of cells of such a size that twelve side by side make up its circumference. The concave-conoid rectum equals the anal body-diameter in length. What had every appearance of being the excretory pore occurred immediately behind the nerve-ring of every one of the numerous specimens examined. The lateral fields appear to be one-fifth as wide as the body. The tail is conoid to the terminus, which has a diameter one-seventh as great as the anal body-diameter. The vulva is not prominent. The uterus is as long as the reflexed part of the ovary, which reaches two-fifths the way back to the vulva. The ova are arranged single file. This worm is well drawn on Pl. XXXVI.

Hab.—Found in soil about the roots of banana plants, Fiji. No males were seen.

3. **M. crassiusculus,** Dujardin. $\frac{?\quad ?\quad 18{\cdot}6\quad 66{\cdot}\quad 80{\cdot}}{?\quad ?\quad ?\quad 4{\cdot}3\quad ?}$ ·6 mm. This seems to be a doubtful or insufficiently-described species.

Hab.—France.

4. **M. Tunbridgensis,** Bastian. $\frac{3{\cdot}\quad ?\quad 23{\cdot}\quad 60+\quad 89{\cdot}}{3{\cdot}4\quad ?\quad 5{\cdot}4\quad 5{\cdot}5\quad 3{\cdot}2}$ 1·1 mm. This species is well characterised by the head diminishing in size opposite the base of the pharynx.

Hab.—Tunbridge, England.

5. **M. tridentatus,** de Man. $\frac{2{\cdot}\quad 6{\cdot}5\quad 22{\cdot}\quad `62'^{30}\quad 89{\cdot}}{2{\cdot}1\quad 2{\cdot}6\quad 3{\cdot}\quad 3{\cdot}1\quad 1{\cdot}9}$ 3·2 mm. As its name indicates, this species possesses three teeth; they are of equal size, their apices being situated somewhat in front of the middle of the triquetrous pharynx. The œsophagus gradually widens posteriorly. The intestine, which is two-thirds as wide as the body, is separated from the œsophagus by a transparent cardiac region. The rectum is three-fourths as long as the anal body-diameter. The tail is conoid in both sexes. $\frac{2{\cdot}\quad 6{\cdot}5\quad 22{\cdot}\quad M\quad 91{\cdot}}{2{\cdot}1\quad 2{\cdot}6\quad 3{\cdot}\quad 3{\cdot}1\quad 2{\cdot}}$ 2·7 mm. The male has a ventral row of fifteen to seventeen papillæ in front of the anus, and presents also both dorsal and ventral papillæ on the tail. Each of the two equal slender arcuate spicula has a median stiffening piece of chitin. The accessory piece is two-parted, dentate, and encloses the spicula. Oblique copulatory muscles appear to be present.

Hab.—Moist soil, Holland; not common.

6. **M. brachyurus,** Bütschli. $\frac{?\quad ?\quad 24{\cdot}\quad `62'\quad 97{\cdot}5}{?\quad ?\quad ?\quad 3{\cdot}6\quad ?}$ 1·5 mm. The nearly cylindrical neck of this active species is said to terminate in a truncate head bearing a *single* row of rather large papillæ. The beaker-shaped pharynx is one-third as wide as the head, and twice as long as wide. Rasp-like areas on the wall of the pharynx oppose the dorsal tooth. The tail is conoid, blunt and arcuate. Two ventral papillæ are found near the vulva, one in front of it and one behind it. The reflexed portions of the

ovaries are short. $\frac{?\quad ?\quad ?\quad \mathrm{M}\quad 97\cdot}{?\quad ?\quad ?\quad 2\cdot7\quad ?}$ 1·7 mm. The tail of the male resembles that of the female in form. A ventral row of ten to eleven large papillæ occurs in front of the anus. Dorsal as well as ventral papillæ are found on the tail. Each of the two equal arcuate spicula is stiffened by an extra central piece of horn. The accessory piece is two-parted and surrounds the spicula.

Hab.—Soil in meadows, Western Europe; common.

7. **M. parvus,** de Man. $\frac{3\cdot1\quad 9\cdot5\quad 29\cdot\quad `63\cdot'\quad 93\cdot}{3.\quad 3\cdot6\quad 4\cdot7\quad 5\cdot2\quad 3\cdot}$ 1·1 mm. The conoid neck terminates in a head with an expanded lip-region bearing the usual two circles of papillæ of which the inner are the larger. The pharynx is a little over one-third as wide as the head, the dorsal tooth being small and central. There are two small submedian teeth at the base of the pharynx. The intestine is two-thirds as wide as the body and ends in a rectum two-thirds as long as the anal body-diameter. The reflexed ovaries reach three-fourths the way back to the vulva.

Hab.—This active species is common in sandy meadows, Holland.

8. **M. cristatus,** Bastian. $\frac{3\cdot\quad ?\quad 29\cdot\quad `50'+\quad 87\cdot}{3\cdot8\quad ?\quad 5\cdot4\quad 5\cdot5\quad 3\cdot2}$ 1·1 mm. The œsophagus is about half as thick as the neck. The intestine is two-thirds as wide as the body and ends in a rectum two-thirds as long as the anal body-diameter.

Hab.—England.

9. **M. minor,** n.sp. An immature female gave the formula $\frac{3\cdot2\quad 10\cdot\quad 30\cdot\quad 60\cdot\quad 95\cdot}{3\cdot1\quad 3\cdot7\quad 4\cdot3\quad 4\cdot3\quad 2\cdot7}$ 1· mm. The head is less truncate than usual. What appear to be lateral organs occur opposite the anterior part of the pharynx. This latter is pyriform, being broadest anteriorly and is approached through a narrow vestibule nearly one-third as long as itself. The thumb-shaped dorsal tooth projects half way across the pharyngeal cavity somewhat above the middle, and is opposed by half-a-dozen transverse rows of rasp-like teeth one micromillimetre apart, the upper of these rows being opposite the apex of the tooth and the lower opposite its middle. The intestine is three-fifths as wide as the body, and the rectum is nearly equal to the anal body-diameter in length. The lateral fields are one-third as wide as the body. The terminus of the tail is one-third as wide as the base. The anatomy of this worm is well set forth on Pl. XXXVI.

Hab.—In soil about banana plants, Fiji, 1891.

10. **M. papillatus,** Bastian. $\frac{2\cdot5\quad ?\quad 23\cdot\quad `67\cdot'\quad 93\cdot}{2\cdot3\quad ?\quad 3\cdot8\quad 4\cdot\quad 2\cdot5}$ 1·5 to 2·5 mm. The triquetrous pharynx is about one-third as wide as the head, and has the rather small dorsal tooth situated a little in front of the middle. The intestine is two-thirds as wide as the body.

Hab.—Among moss and grass, Western Europe; common.

11. **M. muscorum**, Dujardin. $\frac{2\cdot \quad 9\cdot \quad 24\cdot \quad {}^{\cdot}65\cdot^{32} \quad 94\cdot}{2\cdot1 \quad 2\cdot7 \quad 3\cdot2 \quad 3\cdot6 \quad 1\cdot6}$ 2·5 to 3 mm. The small dorsal tooth is near the centre of the pharynx, which is nearly one-half as wide as the head. The somewhat conoid œsophagus is three-fourths as wide as the neck, and the intestine is three-fourths as wide as the body. The rectum equals the anal body-diameter in length. The tail diminishes somewhat more rapidly near the terminus. The reflexed ovaries, each containing about a dozen ova arranged single file, extend half-way back to the projecting vulva. The eggs are one and one-half times as long as the body is wide, and three-fifths as wide as long. The anterior sexual organ is somewhat the larger.

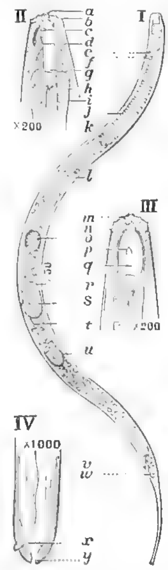
Hab.—Among moss, &c., Western Europe.

12. **M. major**, n.sp. $\frac{1\cdot6 \quad 6\cdot \quad 19\cdot \quad {}^{\cdot}55\cdot^{25} \quad 95\cdot}{1\cdot6 \quad 2\cdot2 \quad 2\cdot6 \quad 2\cdot9 \quad 1\cdot5}$ 3·4 mm. The conoid neck terminates anteriorly in a truncate head bearing two rows of papillæ arranged as usual. The lateral organs are small and are situated near the lips,—slightly further forward than the point of the dorsal tooth. The narrow mouth leads into a pharynx as long as the head is wide, and two-fifths as wide as long, pointed at the bottom and strongly lined with chitin. The tooth, which, though small, is conspicuous, is situated considerably in front of the middle of the pharynx. The lateral fields are one-fifth as wide as the body. The intestine, which is marked off from the œsophagus by a shallow but distinct constriction, is greenish in colour, and composed of rather small cells showing an indistinct tessellation; the rectum is equal in length to the anal body-diameter. The conoid tail is ventrally arcuate, and ends in a blunt terminus containing a spinneret of the usual form. The eggs are probably less than twice as long as wide. The reflexed ovaries reach about half-way back to the vulva. $\frac{1\cdot5 \quad 6\cdot6 \quad 19\cdot \quad \text{—M—} \quad 95\cdot}{1\cdot5 \quad 2\cdot3 \quad 2\cdot9 \quad 2\cdot8 \quad 2\cdot3}$ 3·4 mm. The tail of the male somewhat resembles that of the female in general form, but is more strongly arcuate. The spicula are elongated, arcuate, tapering toward both ends, not cephalated, and twice as long as the anal body-diameter, and are situated close together; the accessory pieces are well developed, and surround the spicula behind the middle, their blunt proximal points appearing in front of the ventral contour of the spicula. The protruding-muscles of the spicula are attached to the body-wall near the middle of the tail. A ventral row of about twelve conspicuous innervated mammiform accessory organs occur in front of the anus, and extend over a space about twice as long as the tail; each organ is situated on the posterior side of a transverse chitinous ridge extending one-fourth the distance round the body. The anterior two or three and the posterior one of these organs are smaller than the others; they are equidistantly placed, except the posterior, which is removed somewhat from its fellows. Oblique copulatory muscles are found co-extensive with the accessory organs and the crenate ejaculatory duct. The testicles occupy the middle third of the body. There are two pairs of ventrally submedian papillæ, also

innervated, on the anterior third of the tail, the posterior pair being near the end of the anterior third and the other pair half-way between that point and the anus. There are other papillæ (?) faintly visible on the dorsal side of the tail and elsewhere.

Hab.—Roots of plants, damp soil, Moss Vale, New South Wales.

13. **M. longicaudatus**, n.sp. $\frac{2\cdot5 \quad 7. \quad 23\cdot \quad {}^{\cdot}52\cdot^{21} \quad 84\cdot}{2\cdot2 \quad 2\cdot7 \quad 3\cdot2 \quad 3\cdot7 \quad 1\cdot9}$ 1·6 to 1·9 mm. Behind the nerve-ring the neck is conoid; but anteriorly it becomes slightly convex-conoid. The small elliptical lateral organs are placed close behind the outer row of papillæ, their long diameter being placed transversely; when seen in profile they appear as slits from which a process is seen to pass inward and backward. The pharynx, which is three-fifths as wide as the head and three times as long as wide, bears a rather small dorsal tooth near the middle, and very inconspicuous rudimentary projections on the ventral side. The vestibule is shorter than usual. The œsophagus is three-fifths as wide as the neck, its lumen being conspicuous because of the thickness of the chitinous lining. The cardia is large and well developed, and the intestine, which is four-fifths as wide as the body, is composed of cells of such a size that about twelve are required to build up the circumference. The concave-conoid rectum is as long as the anal body-diameter. The lateral fields are one-seventh as wide as the body. The tail tapers most rapidly in the anterior half; posteriorly it is one-fifth as wide as at the anus. The reflexed ovaries extend half way back to the inconspicuous vulva and each contains fifteen to twenty eggs arranged about three abreast. The eggs are one and one-half times as long as the body is wide and one-half as wide as long. Segmentation appears to begin before the eggs are deposited,—at least in one case I observed an egg that had formed the first two blastomeres while yet in the uterus.



a, mouth.
b, labial papilla.
c, lateral organ.
d, dorsal tooth.
e, excretory pore.
f, nerve-ring.
g, pharynx.
h, pharyngeal muscles.
i, *j*, œsophagus.
k, cardiac region.
l, intestine.
m, labial papilla.
n, lateral organ.
o, ovum.
p, dorsal tooth.
q, pharynx.
r, egg with shell.
s, vulva.
t, blind end of posterior ovary.
u, bend in ovary.
v, anus.
w, three caudal glands.
x, one of two papillæ on the end of tail.
y, outlet for caudal glands.

FIG. 2.—I, female *Mononchus longicaudatus*; II, side view of head of same worm; III, ventral view of head of same worm; IV, end of tail of same worm.

Hab.—Blanched part of celery, abundant, Sydney, N.S.W., Australia.

14. **M. truncatus**, Bastian. $\frac{2\cdot5 \quad ? \quad 25\cdot \quad 50+ \quad 86\cdot}{3\cdot \quad ? \quad 5\cdot \quad 5\cdot3 \quad 3\cdot4}$ 1·75 mm. The elongated pharynx is one-third as wide as the head, the blunt dorsal tooth being situated near its middle. The intestine is three-fourths as wide as the body and the rectum is two-thirds as long as the anal body-diameter. Tail in the anterior two-thirds conoid, thence cylindrical and one-fourth as wide as at the anus. $\frac{2\cdot5}{?} \frac{?}{?} \frac{25\cdot}{?} \frac{M}{?} \frac{92\cdot}{?}$ 2· mm. The male tail

is more slender, the posterior two-thirds being cylindrical and only one-sixth as wide as at the anus. A ventral row of eighteen or nineteen equidistant papillæ or accessory organs is found just in front of the anus. The low post-anal papillæ are arranged as follows: 1, near the anus a pair of ventral submedian; 2, near the other end of the anterior third of the tail another pair of ventral submedian; 3, on the middle third of the tail three dorsal; 4, on the terminus two. The two equal setaceous spicula are about half as long as the tail, their distal halves being arcuate and their proximæ cephalated by slight expansion. The two slender accessory pieces are parallel to the spicula and two-fifths as long.

Hab.—Among moss and aquatic plants, and in mud and sand near by, Western Europe.

15. **M. microstoma**, Bastian. $\frac{2{\cdot}3 \quad 7 \quad 25{\cdot} \quad `50' \quad 90{\cdot}}{2{\cdot}5 \quad 3{\cdot}1 \quad 3{\cdot}6 \quad 3{\cdot}4 \quad 3{\cdot}}$ 2·5 mm. The labial papillæ of the inner row are the larger. The dorsal tooth is located a little in front of the middle of the elongated pharynx and is opposed by transverse chitinous ridges on the wall of the ventral side of the cavity. There are also small teeth at the base of the pharynx. The intestine is two-thirds as wide as the body and the rectum is one-half as long as the anal body-diameter. The anterior fourth of the tail is conoid; thence it is very narrow to the slightly swollen terminus. The form of the male is similar to that of his mate. There is a ventral row of twenty pre-anal papillæ, and three ventral, as well as some lateral, post-anal ones. The slender spicula are bent at a blunt angle. The accessory piece is slender and much shorter than the spicula. Oblique copulatory muscles appear to be present.

Hab.—Fresh soil and fresh water, Holland, common; England.

16. **M. fovearum**, Dujardin. $\frac{? \quad ? \quad 14{\cdot}8 \quad 50{\cdot} \quad 93{\cdot}}{? \quad ? \quad ? \quad 3{\cdot} \quad ?}$ 2·5 mm. This species is insufficiently known.

Hab.—France.

GENUS CHROMADORA, Bastian.

1. **C. minima**, n.sp. $\frac{2{\cdot}8 \quad 11{\cdot} \quad 20{\cdot} \quad 43{\cdot} \quad 84{\cdot}}{3{\cdot}3 \quad 3{\cdot}8 \quad 4{\cdot}3 \quad 4{\cdot}8 \quad 3{\cdot}2}$ ·4 mm. is the formula found from the measurements of the only two specimens seen, both immature females. The cuticle is traversed by very fine transverse striæ resolvable with the highest powers of the microscope into rows of dots. The cylindroid neck is capped by a truncate head bearing on its outer margin six spreading setæ, each about one-sixth as long as the head is wide. The number of lips appears to be twelve, as indicated by the number of longitudinal ribs round the mouth opening. The spiral lateral organs are situated

a trifle behind the bottom of the pharynx; each is a spiral one-fourth as wide as the neck, the right being a left-handed spiral of two turns, and the left being a similar right-handed spiral. The pharynx differs somewhat from that of the typical *Chromadora* as known to me, and this has led me to believe that it will soon be found necessary to re-group the species of this genus, and possibly to create new genera for the reception of some of them. Roughly speaking, the pharynx has the form of a triquetrous pyramid. The dorsal tooth is situated somewhat behind the middle of the pharynx, and when seen in profile appears to be arched over near its apex by a process above it. Opposite the dorsal tooth occurs a ventral projection somewhat resembling a rudimentary tooth inverted. The animal is so very small that these particulars can only be made out with high powers. There are no eyes. The œsophagus is one-half as wide as the neck and ends posteriorly in a spheroidal swelling two-thirds as wide as the neck. The cardiac constriction is very deep and conspicuous. The intestine is two-thirds as wide as the body, and its cells contain granules of various sizes. The conoid rectum somewhat exceeds the anal body-diameter in length. The anus is much depressed. The tail tapers very little, being one-half as wide at the apiculate terminus as at the base. Caudal glands are present. The vulva projects somewhat. Two sketches of this *Chromadora* are given on Pl. XXXVII.

Hab.—Soil about the roots of banana plants, Fiji, July, 1891.

C. Musæ, n.sp. $\frac{2{\cdot}4 \quad 7{\cdot} \quad 17{\cdot} \quad ? \quad 86{\cdot}}{2{\cdot}6 \quad 3{\cdot}3 \quad 3{\cdot}5 \quad ? \quad 2{\cdot}8}$ The cuticle has much the same structure as in *C. minima*. The cylindroid neck is surmounted by a rather truncate head bearing no setæ, or such that they escaped observation with very high powers. The spiral lateral organs are placed opposite the middle of the pharynx, each being one-fourth as wide as the head; the right-hand organ is a left-handed spiral of two turns and the left-hand organ is a similar right-handed spiral. The approach to the pharynx is cyathiform and ribbed as is usual in this genus. The pharynx is somewhat irregularly elongated and the dorsal tooth small and so situated that its blunt apex is somewhat further back than the lateral organs. The œsophagus is slightly expanded to receive the pharynx, but through the greater portion of its length it is only one-third to one-half as wide as the neck; posteriorly it expands to form a prolate bulb three-fourths as wide as the base of the neck. The nerve-ring is narrow and somewhat oblique. Nothing was seen of the ventral excretory organ or its pore. The intestine is two-thirds as wide as the body. The tail is conoid to the apiculate terminus. Three sketches of this worm, which is of about the same size as *C. minima*, are given on Pl. XXXVII.

Hab.—Found in soil about the roots of banana plants, Fiji, July, 1891.

GENUS DIPLOGASTER, Schultze.

The genus *Diplogaster* is composed of free-living forms, not marine, characterised by the possession of a large pharynx armed with one or more teeth, and an œsophagus with two well developed bulbs. If only one tooth is present it is dorsal; if more than one, then the larger may be dorsal and the others subsidiary, or more often all may be small and basal. The average dimensions are indicated by the following formulæ :—$\frac{1{\cdot}6 \quad 11{\cdot} \quad 16{\cdot} \quad {}^{\backprime}48^{\prime 23} \quad 73{\cdot}}{2.4 \quad 3{\cdot}6 \quad 4{\cdot} \quad 4{\cdot} \quad 1{\cdot}9}$ 1·11 mm. $\frac{1{\cdot}6 \quad 10{\cdot}9 \quad 16{\cdot} \quad {}^{\backprime}M^{37} \quad 76{\cdot}}{12{\cdot} \quad 2{\cdot}8 \quad 3{\cdot} \quad 3{\cdot} \quad 2{\cdot}5}$ 1·mm The cuticle is commonly transversely striated, though apparently sometimes not, and moreover presents longitudinal striations or perhaps more properly speaking wings, sometimes to the number of forty, of which those on the lateral fields are usually more prominent, they being the only ones that continue far on the tail. Both these sorts of markings are often resolvable into rows of dots or circles. The only hairs thus far observed on the body are the cephalic setæ seen on a few species, and those on the male: these latter are doubtless tactile and partake more of the nature of papillæ than of ordinary hairs; their arrangement and grouping will presently be described. The papilla-like cephalic setæ number four, or possibly six, and are always small and very inconspicuous; they are situated somewhat behind the outer border of the truncate head. The lips, three in number, are sometimes single and sometimes double, and are supplied with papillæ, usually six, arranged around the mouth. The entrance to the pharynx is usually wide and is often striated longitudinally. The proportions of the pharynx vary much and serve very well to characterise the different species; sometimes the pharynx is shallow and cyathiform, and sometimes long and triquetrous. The variation in the armature of the pharynx is no less remarkable. Some species possess a single large dorsal tooth whose apex is directed forward and situated near the centre of the pharynx, while other species possess but a small or even rudimentary dorsal tooth; yet other species seem to entirely lack a dorsal tooth, and present instead a number of small teeth at the very base of the pharynx.

The œsophagus invariably possesses two well developed bulbs and sometimes three: of these the spheroidal median is the most conspicuous, being supplied with powerful radial muscles; the more elongated cardiac bulb is second in importance and is also supplied with well developed radial muscles; the pharyngeal bulb is the least conspicuous and is in fact nothing else than the expansion due to the presence of muscles attached to the parts of the pharynx. Of the intermediate tubular parts of the œsophagus, that between the pharynx and the median bulb is usually about half as wide as the conoid neck and twice as wide as the other,—that between the median and cardiac bulb,—and much less flexible. Some species possess a marked power of contracting and extending the neck; in the contracted state the intestine

forms a shoulder in the cardiac region. Eye spots are unknown in the genus. The oblique nerve-ring encircles the œsophagus just behind the median bulb. The ventral excretory pore lies somewhat behind the nerve-ring. Lateral organs have been observed in but few of the species but this is doubtless due to insufficient care in observation; no doubt they exist in all the species. Where they have been observed they have been found to be placed opposite the pharynx and to be more or less elongated or elliptical in form and to have their long diameter placed longitudinally. In one species a glandular organ seems to exist in the œsophagus and to empty in the neighbourhood of the dorsal tooth. The intestine is usually thin-walled and ends in a rectum of the usual conoid form.

The female sexual organs are usually double, symmetrical and reflexed, but in two species are single and reflexed. The tail is invariably conoid and is usually exceedingly slender in its posterior part. Caudal glands of the usual form are absent, there being no terminal pore or spinneret. There are, however, on the tail of both sexes, commonly in front of its middle point, two lateral pores, one on either side, which are in my opinion the outlet of unicellular glands situated near the anus. These pores and glands exist also in the genus *Rhabditis*. Whether they are the morphological equivalents of the tail-glands in other genera I am not certain. It would seem that they cannot at any rate serve the same purpose as the ordinary arrangement as exhibited in *Plectus* and many other genera. The male has but one testicle, which is invariably reflexed near the extremity. The two arcuate spicula are equal in size and are elongated or linear and generally acute. Their proximal ends are usually cephalated by expansion; accessory pieces parallel to the spicula are usually present. The peculiar papillæ found on the tail of the male are divided into three groups of three each, a grouping first made plain through the observations of Dr. Bütschli. The full complement of papillæ is not always present, or at least has not always been made out; when however one or more pairs are absent, their position appears simply to stand vacant, and their absence does not much affect the position of those remaining. The first group may be described as the pre-anal group, and its members are ventrally submedian, or the posterior one may be lateral; they are situated opposite to, or in the neighbourhood of, the spicula. The second group is post-anal and the members of it are often more widely separated than those of the pre-anal group, the anterior pair being usually ventrally submedian or even subdorsal. The posterior pair of the second group frequently lies farther back than the papillæ of the third group. The latter, also post-anal, are placed close together on the submedian line near where the tail diminishes most rapidly in size. In shape the papillæ resemble hairs, and, in fact, may be such, but with a special function. Those of the third group, however, are different, being often more like ordinary papillæ in structure. No other

supplementary male organs are known in the genus except papillæ of another character near the anus.

There is an interesting dorsal organ on the head,—of unknown significance. It will be noticed in the description of the species in which it has been observed.

KEY.

- Pharynx with one or two large teeth.
  - Tail end (female at least) encircled by a few conspicuous rings .... 1. *viviparus.*
  - Tail end not so encircled.
    - Length of the female not exceeding 1· mm.
      - Body slender (little more than 2·6 %); neck long (23· %) .... 2. *parvus.*
      - Body not so slender (3 % and over); neck shorter (13· % to 22· %).
        - Female sexual organs asymmetrical (single).
          - Œsophagus 16 % .... 3. *monhysteroides.*
          - Œsophagus 20 % .... 4. *minor.*
        - Female sexual organs double and symmetrical.
          - Reflexed ovaries crossing each other .... 5. *filicaudatus.*
          - Reflexed ovaries not crossing.
            - Œsophagus swollen just behind the pharynx .... 6. *australis.*
            - Œsophagus not so swollen.
              - Body ·4 mm. long .... 7. *minima.*
              - Body ·75 mm. long .... 8. *graminum.**
    - Length of the female 1·5 mm. or more.
      - Throat or pharynx with two equally well developed teeth .... 9. *fluviatilis.*
      - Throat or pharynx with only one well developed tooth.
        - Tail about half as long as the worm .... 10. *trichuris.*
        - Tail about one-third as long as the worm .... 11. *striatus.*
        - Tail about one-seventh (15 %) as long as the worm.
          - Length 1·5 mm. .... 12. *macrodon.*
          - Length 2· to 2·5 mm. .... 13. *rivalis.*
- Pharynx with only much less well developed teeth at the base.
  - Female sexual organs single, asymmetrical .... 14. *gracilis.*
  - Female sexual organs double, symmetrical.
    - Throat or pharynx shallow (half as deep as wide).
      - Lips distinct; pharynx not striated .... 15. *inermis.*
      - Lips indistinct; pharynx striated .... 16. *similis.*
    - Throat or pharynx as deep as wide, with small teeth at the base.
      - Length exceeding 1· mm.
        - Tail nearly one-third (30 %) as long as the worm .... 17. *longicauda.*
        - Tail only one-fifth (16 to 20 %) as long as the worm.
          - Width 4· % .... 18. *filiformis.*
          - Width exceeding 7 % .... 19. *albus.*

* The unknown female of *graminum* is assumed to have double and symmetrical sexual organs not crossing.

Key to the Males Described.

Pharynx with two large teeth	9. *fluviatilis.*
Pharynx with only one large tooth.	
Spicula unknown	18. *filiformis.*
Spicula not exceeding the anal body-diameter in length.	
Proximæ furcate	12. *macrodon.*
Proximæ cephalated by constriction, not furcate	16. *similis.*
Proximæ neither cephalated nor furcate	8. *graminum.*
Spicula exceeding the anal body-diameter in length.	
Tail 40 % or so	10. *trichuris.*
Tail 30 % or so.	
Pharyngeal tooth basal	6. *australis.*
Pharyngeal tooth not basal.	
Body longitudinally striated	11. *striatus.*
Body not so striated	2. *parvus.*
Tail about 15 % or 20 %.	
Length not exceeding 1 mm.	
Proximæ of the spicula geniculate	17. *longicauda.*
Proximæ of the spicula not geniculate.	
Throat or pharynx with a well developed tooth	7. *minima.*
Throat or pharynx with no well developed tooth	14. *gracilis.*
Length 2·5 mm.	13. *rivalis.*

1. **D. viviparus,** von Linstow. $\frac{1\cdot5 \quad ? \quad 14\cdot \quad 50\cdot \quad 86\cdot}{1\cdot5 \quad ? \quad 2\cdot1 \quad 2\cdot1 \quad 1\cdot3}$ 1·8 mm. Cuticle finely transversely striated. In front of the anus three, and on the anterior third of the tail five, prominent rings encircle the body. On the ventral side of the hindermost of these rings occurs a circular organ with a circular centre, the whole being as wide as the tail at that point. Head truncate, but with a broad projection at the mouth ; setæ none ; lips uncertain ; pharynx as deep as the head is wide and two-thirds as wide as the head, constricted in the middle, with some teeth of unequal size at the base ; pharyngeal swelling elongated, tapering behind; median bulb considerably behind the middle of the neck ; posterior swelling much elongated, tapering anteriorly ; tail conical, tapering from in front of the anus; caudal glands none; viviparous; embryos slender, without the chitinous structure on the head.

Hab.—Water plants, Germany. It is perhaps questionable whether this is a *Diplogaster.*

2. **D. parvus,** n.sp. Female unknown. $\frac{1\cdot6 \quad 15\cdot \quad 23\cdot \quad \text{'M}^{20} \quad 68\cdot}{1\cdot3 \quad 2\cdot4 \quad 2\cdot6 \quad 2\cdot6 \quad 2\cdot3}$ ·6 mm. Neck conoid; head truncate, with six lips, each with one papilla ; pharynx elongated, crooked, anterior part wider, the tooth appearing as a prominence and without a distinct and projecting apex ; œsophagus slender, the anterior part being only one-third as wide as the neck ; bulbs one-half as wide as the neck ; intestine three-fourths as wide as the body ;

position of the excretory pore unknown ; two wings on the lateral field separated by a distance equal to one-fourth the width of the body. The tail is conical, and is arcuate in the anterior part. The anus is rather prominent. The two equal elongated-cuneiform acute arcuate spicula slide in an accessory piece having a backward-pointing somewhat hook-shaped process, which if straightened out and extended forward would reach nearly to the proximæ. The male papillæ are finger-shaped and are arranged as follows : 1, a sublateral pair as far in front of the proximal ends of the spicula as the latter are in front of the anus ; 2, one submedian pair just in front of the proximæ ; 3, one subventral pair just in front of the anus ; 4, one submedian pair as far behind the anus as the first pair mentioned above is in front of it ; 5, and finally, a ventral post-anal group (two pairs ?) twice as far from the anus as those last mentioned. All these details, as well as many others, are set forth on Pl. XXXIX.

Hab.—On decaying outside sheaths of young banana plants, Fiji, July, 1891.

3. **D. monhysteroides**, Bütschli. $\frac{?\quad ?\quad 17\cdot\quad 50\cdot\quad 58\cdot}{?\quad ?\quad ?\quad 3\cdot8\quad ?}$ ·79 mm. The neck diminishes more rapidly than in *filicaudatus ;* it resembles that species, however, in the structure of the pharynx, except that the pharynx of *monhysteroides* is somewhat narrower. The female sexual organs are asymmetrical, there being, however, a posterior sterile branch reaching nearly to the anus.

Hab.—This species, which much resembles the *filicaudatus* of the same author, was found with that species in cow-dung, Germany.

4. **D. minor**, n.sp. $\frac{1\cdot6\quad 13\cdot\quad 20\cdot\quad {}^{\backprime}49^{20}\quad 63\cdot}{1\cdot7\quad 2\cdot9\quad 2\cdot9\quad 3\cdot2\quad 2\cdot}$ ·5 mm. No markings were observed on the cuticle, which was without hairs as well. A three-lipped truncate head surmounts the conoid neck. Each lip bears a setose papilla. The pharynx is about as deep as the head is wide, and in its widest part is half as wide as the head ; the single large acute dorsal tooth springs from the base of the pharynx and extends nearly half-way to the mouth. The œsophagus does not expand to receive the pharynx but assumes immediately a width three-fifths as great as the neck and so continues to the ellipsoidal median bulb, which is three-fourths as wide as the neck ; behind the median bulb the œsophagus is narrower, passing through the nerve-ring with a width one-third as great as that of the neck but expanding finally to form a bulb somewhat smaller than the median bulb. The intestine, which is separated from the œsophagus by a distinct cardiac constriction, is rather coarsely granular, and ends in a rectum having a length equal to that of the anal body-diameter. The conical tail is excessively fine near its end. No caudal glands were seen. The reflexed part of the ovary extends nearly half-way back to the inconspicuous vulva. The rather thick-shelled eggs are a little more than twice as long as the body is wide, and one-third to one-fourth as wide as long, being, therefore, of such a large size that the uterus will

contain but one at a time. I do not know whether segmentation begins before the eggs are deposited. Male unknown. Figures of this species are given on Pl. XXXIX. along with those of *D. parvus.*

Hab.—On decaying outside sheaths of young banana plants, Fiji, July, 1891.

5. **D. filicaudatus**, Bütschli. $\frac{2\cdot(?)\quad ?\quad 13\cdot\quad \text{‘}50\text{’}\quad 68\cdot}{2\cdot(?)\quad ?\quad ?\quad 3\quad ?}$ $1\cdot$mm. Neck conoid ; cephalic setæ apparently four ; pharynx nearly as deep as the head is wide, and more than one-half as wide as the head ; dorsal tooth projecting and thumb-shaped, reaching nearly to the middle of the pharynx ; near the bottom of the pharynx two small submedian teeth. The uterus appears never to contain more than one egg at a time.

Hab.—Cow-dung, Germany.

6. **D. australis**, n.sp. $\frac{1\cdot4\quad 12\cdot\quad 17\cdot5\quad \text{‘}49\cdot\text{’}\quad 77\cdot}{2\cdot\quad 2\cdot7\quad 3\cdot\quad 3\cdot3\quad 2\cdot}$ $\cdot59$ mm. I cannot state positively whether this female is not the mate of that described later on under the name *D. graminum.* They were found together and have the same proportions, but there are marked differences in the structure of the pharynx in the two specimens. In the present species the cuticle is finely transversely striated. The pharynx is twice as deep as wide, being simply deeply cyathiform in shape, and two-fifths as wide as the head. The dorsal tooth is simple in character and extends half-way to the lips. Just behind the pharynx the œsophagus is somewhat swollen, its greatest width in this part being considerably less than that of the ellipsoidal median bulb, which is four-fifths as wide as the middle of the neck. The posterior bulb is longer and narrower than the median. Between the pharyngeal and the median bulbs the œsophagus is two-fifths as wide as the neck, but between the median and cardiac bulbs it is only one-third as wide as the neck. The intestine is very narrow at first,—only one-fourth as wide as the body,—but soon becomes three-fourths as wide as the body. The narrow rectum considerably exceeds the anal body-diameter in length. The reflexed ovaries reach nearly back to the vulva and contain numerous ova arranged in several rows. The eggs are twice as long as the body is wide and one-third as wide as long. The tail is conoid, being setaceous in the posterior half.

Hab.—Grass, Sydney, New South Wales, Australia.

7. **D. minima**, n.sp. $\frac{2\cdot\quad 17\cdot\quad 22\cdot\quad \text{‘}43\cdot\text{’}^{28}\quad 68\cdot}{2\cdot\quad 4\cdot4\quad 4\cdot8\quad 4\cdot8\quad 2\cdot4}$ $\cdot4$ mm. The cuticle is traversed longitudinally by about fourteen equidistant striæ or wings, so arranged that one of them does *not* fall on a lateral line, resolvable into dots $\cdot7\mu$ apart, thus indicating the presence also of about six hundred transverse striæ. Neither setæ nor lateral organs were seen. The triquetrous pharynx is about one-fifth as wide as the head ; the dorsal tooth is elongated and projects but slightly, although its apex approaches to near the lips. The ellipsoidal median bulb is two-thirds as wide as the neck, the cardiac bulb being, as usual, somewhat smaller and weaker. The transparent thick-walled

intestine is two-thirds as wide as the body, its cells containing coarse granules. The cardia is deep and the cardiac cavity is distinct. The anterior half of the tail is conoid, the posterior half setaceous. The reflexed ovaries reach nearly to the slightly projecting vulva. The thin-shelled eggs are two-thirds as long as the body is wide and two-thirds as wide as long, and begin segmenting while in the uterus. $\frac{1\cdot7 \quad 17\cdot \quad 23\cdot \quad {}^{\backprime}M^{40} \quad 78\cdot}{2\cdot \quad 4\cdot6 \quad 4\cdot8 \quad 4\cdot6 \quad 3\cdot6}$ ·38 mm. The anterior two-fifths of the male tail is conoid and ventrally arcuate ; thence it is setaceous. The anal region is slightly elevated. Of the male papillæ at least all three pairs of the closely approximated third group and four other pairs are present. Of these latter four, three pairs occur opposite the middle of the spicula, two being ventrally submedian and close together, and one lateral, slightly farther back ; the fourth pair—lateral—is as far behind the anus as the foremost of the other three is in front of it. The closely approximated three pairs, situated where the tail suddenly narrows, are associated with a slight ventral swelling. The spicula are linear, gently arcuate and nearly twice as long as the anal body-diameter. The slender accessory pieces are somewhat sigmoid in form, their internal ends turning forward, while their opposite ends are applied to the distal parts of the spicula. Only a small portion of the testicle is reflexed. The testicle and vas deferens are of about equal length.

Hab.—Decaying outside sheaths of banana plants, Fiji, July, 1891.

8. **D. graminum**, n.sp. Female unknown.* $\frac{1\cdot5 \quad 9\cdot6 \quad 15\cdot8 \quad {}^{\backprime}M^{35} \quad 69.}{1\cdot9 \quad 2\cdot6 \quad 2\cdot9 \quad 3\cdot2 \quad 2\cdot6}$ ·63 mm. The cuticle is marked transversely by very fine striæ. The pharynx is as deep as the head is wide, and, when seen in profile, appears much narrower in its posterior half than in its anterior half because of the presence in the posterior part of the large and pointed dorsal tooth ; anteriorly the pharynx is half as wide as the head. The ellipsoidal median bulb is two-thirds as wide as the neck and is less elongated and more pronounced than the posterior bulb. The tubular part of the œsophagus is rather uniform in diameter, the anterior half being but little wider than the posterior half. The ventral excretory pore is situated somewhat nearer the cardiac than the median bulb. The granular intestine is three-fourths as wide as the body. The anterior fifth of the tail is ventrally arcuate and conoid; thence onward it is setaceous. The arcuate-cuneiform spicula are equal to the anal body-diameter in length and are supplied with arcuate accessory pieces half as long. These latter are slender and make a slight angle with the spicula. Six pairs of papillæ were seen : 1, a ventrally submedian pre-anal pair opposite the proximal ends of the spicula ; 2, a ventrally submedian pair somewhat behind the anus ; 3, three approximated submedian pairs somewhat in front of the place where the tail becomes rather suddenly setaceous ; 4, a dorsal pair (or only one, I am not positive) somewhat behind the three pairs just mentioned.

Hab.—Grass, Sydney, New South Wales, Australia.

* See, however, *D. australis*, p. 269.

9. **D. fluviatilis**, de Man. $\frac{?\ ?\ 14\cdot\ \ \ `50\cdot'\ \ \ 89\cdot}{?\ ?\ \ \ ?\ \ \ \ 2\cdot1\ \ \ ?}$ 1·8 mm. Cuticle very finely transversely striated; neck conoid, diminishing much; cephalic setæ two, lateral; lateral organs small clefts, alike in both sexes; pharynx with two large teeth of equal size, both edged and pointed and crossed when at rest, in the living state continually biting together; wall of the pharynx in front of the teeth longitudinally striated; portion of the œsophageal tube behind the stout median bulb two-thirds as long as the remainder; tail conical to the hair-fine terminus; oviparous. $\frac{?\ \ ?\ \ 14\ \ \ M\ \ \ 89\cdot}{?\ \ ?\ \ \ ?\ \ \ 1\cdot7\ \ \ ?}$ 1·8 mm. With the exception of two small pairs near the middle of the tail, all the male papillæ are bristle-shaped. The bristle-shaped papillæ are arranged as follows: one pair submedian just in front of the anus, one pair lateral just in front of the anus; one pair submedian a little behind the anus, one pair submedian near the middle of the tail, one lateral pair between the two pairs last mentioned, and, finally, one lateral pair far back. Spicula stout, plump, arcuate; accessory pieces long, rod-shaped.

Hab.—Found in water, Holland; less common than *D. rivalis.*

10. **D. trichuris**, n.sp. $\frac{2\cdot\ \ \ 8\cdot7\ \ \ 12\cdot\ \ \ \cdot28\cdot^{,16}\ \ \ 46\cdot}{2\cdot\ \ \ 2\cdot8\ \ \ \ 2\cdot8\ \ \ \ 3\cdot1\ \ \ \ \ 1\cdot8}$ 1·5 mm. The cuticle is traversed longitudinally by about forty wings and transversely by numerous striæ. The convex-conoid head bears four very short and inconspicuous spreading submedian cephalic setæ arranged opposite the apex of the conspicuous dorsal tooth. Six labial papillæ surround the mouth-opening, which is longitudinally striated inside and supported by longitudinal ribs. The elongated-elliptical lateral organs, one-eighth as wide as the head, are situated parallel to and opposite the middle of the pharynx. This latter is narrow, being only one-fourth as wide as deep, and contains a single large hamate dorsal tooth whose apex is nearly on a level with the lips. This tooth is so large as to pretty well close up the mouth opening. All the organs in the neck are quite typical. The ellipsoidal median and cardiac bulbs are of nearly equal size: though the cardiac if anything is the larger, the median is manifestly the more perfectly developed; they are two-thirds to three-fourths as wide as the neck. The portion of the œsophagus between the pharynx and the median bulb is one-half as wide as the neck and about twice as wide as that part between the two bulbs. The intestine is two-thirds as wide as

a, labial papilla.
b, cephalic seta.
c, one of the ribs of the pharynx.
d, lateral organ.
e, median bulb.
f, nerve-ring.
g, excretory pore.
h, cardiac bulb.
i, *i*, dorsal tooth.
j, salivary gland (?).
k, pharynx.
l, organ of unknown function.
m, reflexed blind end of testicle.
n, proximal end of spiculum.
o, *o*, anterior group of male papillæ.
p, preanal ventral papilla.
q, *q*, *q*, median group of male papillæ.
r, supposed outlet of gland.
s, posterior group of male papillæ.
t, hind end of testicle.
u, ejaculatory duct.
v, anus.
w, anus, female.
x, gland (?).
y, outlet of same.
z, terminus.

FIG. 3.—I, male *Diplogaster trichuris;* II and III, head and anal region of the same, more highly magnified; IV, anal region of the female of the same worm.

the body. The conoid rectum is one and one-half times as long as the anal body-diameter. The reflexed ovaries extend back nearly to the inconspicuous vulva. The position of the ventral gland remains unknown, but the ventral pore, its outlet, is situated just behind the nerve-ring. Two lateral glandular organs occur opposite the rectum, each emptying through a lateral pore near the middle of the thicker conoid anterior part of the tail. Inside the œsophagus, too, a gland appears to exist and to empty its secretion into the pharynx in the neighbourhood of the dorsal tooth. A dorsal organ occurs on the head, at least of the male; this I have figured. Its function is a mystery to me; I can only suggest that it is a special male organ of some sort, my reasons being briefly these:—1. I observed it only on the males; nevertheless as I have seen but few females it may have been present on their heads and have escaped me. 2. Oerley has described a "lateral organ" as existing only on the male of his *macrodon*. Is this not perhaps the same organ that I have observed? I think it more than probable. These reasons are not a sufficient basis for a pronounced opinion, but they will serve to call particular attention to this organ in future. The male formula is as follows. $\frac{1{\cdot}8 \quad 9{\cdot} \quad 13{\cdot}6 \quad \text{‘M}^{33} \quad 57{\cdot}}{1{\cdot}7 \quad 2{\cdot}5 \quad 2{\cdot}5 \quad 2{\cdot}5 \qquad 1{\cdot}8}$ 1·27 mm. The tail is similar in form to that of the female. Beside the full complement of nine pairs of finger-shaped papillæ there is a pair of low ventral papillæ just in front of the anus. The nine pairs are arranged as follows: 1, two closely approximated submedian pairs opposite the middle of the distal half of the spicula; 2, a sublateral pair a little farther forward than the low ventral pre-anal pair mentioned above; 3, a submedian pair just in front of the pores forming the outlet of the lateral caudal glands, or in other words just behind the middle of the conoid part of the tail; 4, three closely approximated subventral pairs just in front of where the tail diminishes rather suddenly and becomes setaceous, or in other words near the end of the conoid part of the tail; 5, a subdorsal pair somewhat behind the three pairs just described. The linear spicula taper gradually, but not uniformly, to a slender point; the proximal parts are narrowed also. The accessory pieces are half as long as the spicula and are arranged parallel to them. Only a small portion of the testicle near the blind end is reflexed. The testicle has about the same length as the neck of the worm and occupies a position half way between the cardiac region and the anus. The vas deferens is of somewhat smaller diameter than the testicle and is connected with it by a narrow passage. The ejaculatory duct is apparently quite short.

Hab.—Grass, Sydney, New South Wales, Australia.

11. **D. striatus**, Bütschli. $\frac{? \quad ? \quad 13{\cdot}3 \quad \text{‘}50{\cdot}\text{’} \quad 71{\cdot}}{? \quad ? \quad ? \quad ? \quad ?}$ 1·5 mm. The cuticle is traversed longitudinally by about forty striæ; head rounded-truncate near the mouth, with apparently four setæ; lips scarcely to be detected; pharynx two-thirds as deep as the head is wide, longitudinally striated anteriorly, containing two very small submedian teeth at

the base, and one well-developed and projecting dorsal tooth extending three-fourths the distance to the lips; according to Bütschli, excretory ducts on both sides of the body; uteri containing but few eggs; oviparous; male tail convex-conoid for a distance equal to twice the anal body-diameter, being at that point as wide as the spicula and continuing conoid to the exceedingly fine terminus; two pairs of pre-anal papillæ, one opposite the proximæ and the second opposite the middle of the spicula, both submedian; post-anal papillæ, two pairs submedian opposite the anus, two pairs submedian near the middle of the large part of the tail, and the remaining four pairs approximated near the commencement of the narrow part of the tail; spicula linear, one and one-half times as long as the anal body-diameter, distal halves only arcuate to the acute points; accessory pieces less than half as long as the spicula.

Hab.—Found among decaying masses on the surface of the river Main at Frankfort, Germany.

12. **D. macrodon,** Oerley. $\frac{\cdot 9 \quad ? \quad 12{\cdot}1 \quad `44{\cdot}' \quad 83{\cdot}}{1{\cdot}3 \quad ? \quad 1{\cdot}8 \quad 2{\cdot}2 \quad 1{\cdot}6}$ 1·6 mm. Cuticle with about one thousand transverse striæ; neck nearly cylindrical, convex-conoid near the head; head rounded in front; no cephalic setæ; lips prominent; lateral organs said to be circular with a spot in the middle, nearly as wide as the pharynx, behind the base of which they are situated; pharynx irregularly cylindrical, one-third as wide as the head; dorsal tooth reaching half-way to the lips, the other two only one-third as long but equally pointed; median bulb central, prolate, two-thirds as wide as the neck, somewhat wider than the conoid posterior swelling; the intestine is half as wide as the body and is marked off from the œsophagus by a deep and narrow constriction; excretory pore at 10%, that is, somewhat in front of the cardiac constriction; tail conical from the inconspicuous anus; terminus wider than usual, *i.e.*, not hair-fine; vulva depressed; eggs ellipsoidal, as long as the body is wide and half as wide as long; viviparous; reflexed portions of the ovaries reaching one-fourth the way back to the vulva. $\frac{1{\cdot} \quad ? \quad 12{\cdot} \quad {\cdot}\mathrm{M}^{64} \quad 87{\cdot}}{1{\cdot}3 \quad ? \quad 2{\cdot}5 \quad 2{\cdot}5 \quad 2{\cdot}}$ 1· mm. Male tail conical, its terminus hair-fine; papillæ as follows: one pre-anal pair, submedian, opposite the proximæ; one post-anal ventral near the anus; the remainder post-anal, of which the first is as far behind the anus as the pre-anal submedian pair is in front of it, the second considerably behind the middle of the tail, and the third half-way between the second pair and the terminus; spicula elongated, two-thirds as long as the anal body-diameter, their proximæ enlarged and apparently furcate.

Hab.—Found in Hungary.

13. **D. rivalis,** Leydig. $\frac{1{\cdot} \quad 8{\cdot} \quad 11{\cdot}8 \quad `48{\cdot}' \quad 86{\cdot}}{1{\cdot}3 \quad 1{\cdot}5 \quad 1{\cdot}6 \quad 2{\cdot} \quad 1{\cdot}}$ 2·5 mm. The skin is marked by about thirteen hundred transverse striæ. The truncate head is almost imperceptibly expanded. Six long and fine cephalic setæ surround the mouth, and in addition the male is said to possess a second row of subcephalic setæ. The projecting oval lateral

organs are situated opposite the anterior part of the pharynx and are possessed of a horny centre, being smaller in the females and more like clefts. The stoutly built pharynx is supplied at the middle with an encircling ring; in front of this ring it is longitudinally striated. The dorsal tooth reaches beyond the ring, and there are one or two others near the base of the pharynx. The median bulb is two-thirds as wide as the neck, while the cardiac bulb is an elongated swelling, not bulbous. The brown and somewhat tessellated intestine is marked off from the œsophagus by a distinct constriction; it is said to be composed of not above three rows of cells. The rectum is three-fourths as long as the anal body-diameter. The ventral excretory pore occurs at 9%, that is, considerably in front of the cardiac constriction. The finely-pointed conoid tail is slightly concave somewhat behind the middle and bears a pair of lateral papillæ (pores ?). This species is viviparous, the uteri sometimes containing a dozen embryos. The reflexed ovaries sometimes meet and cross. The proportions of the male are precisely those of his mate, but he is somewhat smaller, usually measuring only 2·mm. Papillæ as follows: only one pre-anal submedian pair just in front of the anus; three lateral equidistant pairs on the anterior half of the tail beginning near the anus; two pairs submedian opposite the lateral three pairs; two pairs subventral close together opposite the anterior pairs of the preceding two groups. The pores (?) found on the female occur also on the male. Spicula slender, arcuate, one and one-half times as long as the anal body-diameter. Accessory pieces one-half as long as the spicula, slipper-shaped, plump, and nearly surrounding the tips of the spicula. Synonym, *D. fictor*, Bastian.

Hab.—Found among fresh-water algæ in Western Europe and England. Has the habit of becoming suddenly still, as if dead

14. **D. gracilis**, Bütschli. $\frac{1{\cdot}5 \quad ? \quad 19{\cdot} \quad {\cdot}65^{\cdot 38} \quad 70{\cdot}}{2{\cdot} \quad 5{\cdot}6 \quad 6{\cdot} \quad 5{\cdot}1 \quad 4{\cdot}}$ ·9 mm. Neck convex-conoid; body wider in the middle than at the vulva, namely 7·3 °/$_\circ$; head rounded-truncate; cephalic setæ six; lips six, broad and flat; pharynx cylindroid, composed of several horny pieces, with possibly two rudimentary teeth at base; both bulbs elongated, the median central, the cardiac weaker; œsophagus twice, the bulbs three times, as wide as the pharynx; intestine large, thin-walled, forming a shoulder in the cardiac region, separated from the œsophagus by a deep constriction so that the collum is only one-fifth as wide; cardia broad and distinct; cardiac cavity two-thirds as wide as the body and very long; rectum half as long as the anal body-diameter; tail concave-conoid, diminishing in the anterior fifth to a width as great as the head, and thence conical to the hair-fine terminus; vulva inconspicuous, with almost invisible radial muscles; vagina one-third as long as the body is wide; eggs same size as median bulb; ovary reaching at least three-fourths the way back to the vulva. The proportions of the male agree fairly with those of the female, but the tail is shorter. Papillæ

as follows: lateral, two pairs opposite the spicula, one opposite the anterior part, the other opposite the posterior part; two pairs submedian close together opposite the anus; three pairs, two submedian and one lateral, just behind the middle of the wide portion of the tail; one pair lateral near the end of the wide part of the tail; spicula very slender, one and one-half times as long as the anal body-diameter; accessory pieces none (?).

Hab.—Found in dung, Germany.

15. **D. inermis,** Bütschli. $\frac{1{\cdot}4 \quad 19{\cdot} \quad 29{\cdot} \quad ? \quad 77{\cdot}5}{4{\cdot}7 \quad 7{\cdot}6 \quad 9{\cdot} \quad ? \quad ?}$ ·5 mm. Female only known. Neck conoid; head truncate; cephalic setæ six, very short; lips six, large, broad and flat; pharynx one-half as wide as the head, cylindroid, one-half as deep as wide, with three teeth at base not well developed; the three bulbs of equal diameter and the median bulb central; intestine at once twice as wide as the bulbs, separated from the œsophagus by a distinct constriction.

Hab.—Found on roots of garlic which had been attacked by insect larvæ, Germany.

16. **D. similis,** Bütschli. $\frac{? \quad ? \quad 9{\cdot} \quad ? \quad 71{\cdot}}{? \quad ? \quad ? \quad ? \quad ?}$ 1·2 mm. Head rounded-truncate; cephalic setæ six, broad and extremely short; lips indistinct; pharynx longitudinally striated, half as wide as the head, half as deep as wide, with three teeth at the base, the dorsal one somewhat larger; eggs ·05 mm. long. A young male gave the following dimensions: $\frac{? \quad ? \quad 15{\cdot} \quad M \quad 67{\cdot}}{? \quad ? \quad ? \quad 3{\cdot}3 \quad ?}$ ·6 mm. Tail contracting but little at first, but behind its middle point becoming conoid suddenly, narrows to a breadth not greater than that of the spicula, and continues thence narrow and conical to the hair-fine terminus; pre-anal setiform papillæ as follows: one pair submedian just in front of the spicula; one pair submedian opposite the middle of the spicula. Post-anal papillæ as follows: two pairs dorsal submedian, one near middle of wide anterior part of the tail (these are perhaps the pores), the other where the tail narrows suddenly; three lateral pairs closely approximated just in front of the pair last mentioned; one ventrally submedian setiform pair somewhat behind the anus; one subventral pair close to anus, not setiform; spicula one-sixth as broad as long, rather blunt, nearly straight, equalling the anal body-diameter in length; accessory pieces two-thirds as long as the spicula.

Hab.—Unknown to me.

17. **D. longicauda,** Claus. $\frac{2{\cdot}\,(?) \quad ? \quad 15{\cdot}4 \quad {\cdot}50{\cdot} \quad 71{\cdot}}{3{\cdot}8\,(?) \quad ? \quad ? \quad 5{\cdot}5 \quad ?}$ 1·1 mm. Cuticle transversely striated; head truncate; cephalic setæ six, very short; lips six, distinct, rounded; pharynx cylindroid, half as long as the head is wide, and as deep as wide, its walls divided into anterior and posterior parts composed of distinct pieces; teeth three, at the base of the pharynx, constantly clapping together; lateral fields broad; eggs ·054 mm. long. $\frac{2{\cdot}\,(?) \quad ? \quad 15{\cdot}4 \quad M \quad 83{\cdot}}{3{\cdot}8\,(?) \quad ? \quad ? \quad 5{\cdot}5 \quad 3{\cdot}6}$ 1· mm. Male tail convex-conoid to in front of the middle, where it is

twice as wide as the spicula, thence conical to the hair-fine terminus; papillæ as follows, all (?) setose: one submedian setose pair in front of the spicula; three lateral pairs, one opposite the anus, one where the tail suddenly diminishes in size, and one half-way between; two ventral submedian rather close together somewhat behind the anus; and three closely approximated subventral pairs at the end of the large part of the tail; spicula linear, one and one-half times as long as the anal body-diameter, posterior two-thirds arcuate, proximal ends geniculate; accessory pieces one-fourth as long as the spicula, and seeming to pretty nearly surround them.

Hab.—Decaying fungi, Frankfort, Germany.

18. **D. filiformis,** Bastian. $\frac{1\cdot8 \quad ? \quad 17\cdot \quad 50\cdot \quad 82\cdot}{2\cdot8 \quad ? \quad 4\cdot \quad 4\cdot1 \quad 2\cdot8}$ ·62 mm. Cuticula marked by about five hundred transverse striæ, also (?) with longitudinal striæ; head truncate; pharynx prismoid, half as wide as the head, deeper than wide, with three teeth at the base; bulbs elongated, half as wide as the neck, the median central; cardiac collum distinct; intestine as wide as the bulbs; rectum two-thirds as long as the anal body-diameter; tail conical to just behind the middle, thence hair-fine. $\frac{1\cdot8 \quad ? \quad 17\cdot \quad \mathrm{M} \quad 76\cdot}{2\cdot8 \quad ? \quad 3\cdot5 \quad 3\cdot5 \quad 3\cdot1}$ ·58 mm. Tail like that of the female; spicula could not be detected.

Hab.—England.

19. **D. albus,** Bastian. $\frac{2\cdot \quad ? \quad 18\cdot \quad 50\cdot \quad 84\cdot}{4\cdot \quad ? \quad 6\cdot5 \quad 7\cdot6 \quad 4\cdot}$ ·60 mm. Cuticle finely transversely striated; neck conoid; head truncate; lips probably six, but very indistinct; pharynx half as wide as the head, as deep as wide, with three teeth at the base; median bulb central, elongated, half as wide as the head; cardiac bulb spherical, two-thirds as wide as the median bulb and connected with it by a constriction one-fourth as wide as the adjacent part of the neck, that is, only half as wide as the anterior part of the œsophagus; cardiac collum distinct; intestine at once half as wide as the body; rectum as long as the anal body-diameter; tail conical to the pointed terminus. Male unknown.

Hab.—England.

20. **D. micans,** Max Schultze. Insufficiently known.

21. **D. liratus,** Schneider *(Leptodera lirata)*. Insufficiently known.

GENUS RHABDITIS.

1. **R. filiformis,** Bütschli. (?). I am not certain that this little species, of which I have seen only the female, is in reality that described by Bütschli under the name *filiformis*. The specimens seen by me gave dimensions as follows: $\frac{3\cdot6 \quad ? \quad 20\cdot \quad `42'^{33} \quad 69\cdot}{2\cdot8 \quad ? \quad 4\cdot \quad 4\cdot \quad 2\cdot}$ ·54 mm. Cuticle plainly but finely transversely striated; neck nearly cylindrical to behind the

pharynx, then convex-conoid to the mouth, which is one-fourth as wide as the base of the neck; lip-region half as wide as the prolate cardiac bulb; only traces of lips; no setæ or papillæ on the head; œsophagus in the anterior half fusiform and about half as wide as the neck, thence narrowing gradually to a tube one-fifth as wide as the neck; cardiac sucking bulb one-half as wide as the neck; cardiac collum distinct, the constriction deep; intestine thick-walled, four-fifths as wide as the body, with a thick transparent lining; cardia small, the cavity large; rectum narrow, nearly twice as long as the anal body-diameter, separated from the intestine by a distinct constriction; ventral excretory pore somewhat behind the middle of the neck (12·5 %); wings of the cuticle nearly as far apart as the opposite sides of the pharynx; tail conoid from the distinct anus, its terminus hair-fine; near the anus two lateral glands which empty through lateral pores at the beginning of the second sixth of the tail; vulva depressed; vagina very short; reflexed ovaries reaching half-way back to the vulva; eggs as long as the body is wide and two-thirds as wide as long. Sketches of this little species are given on Pl. XXXVI.

Hab.—Grass after rain, Sydney, New South Wales, Australia.

2. **R. pellioides**, Bütschli. $\frac{1{\cdot}9 \quad 13{\cdot} \quad 19{\cdot} \quad `49'^{42} \quad 85{\cdot}}{1{\cdot}8 \quad 3{\cdot}8 \quad 4{\cdot}3 \quad 4{\cdot}7 \quad 2{\cdot}5}$ ·8 to 1· mm. Cuticle transversely striated; neck conoid, tapering more rapidly near the head; head truncate; lips six, hemispherical, each with a papilla; pharynx simple, prismoid, one-third as wide as the head; median and cardiac bulbs powerful, subspherical, two-thirds as wide as the neck, the median situated in the middle of the neck; œsophageal tube in front of the median bulb half as wide as the neck, behind the bulb one-third; ventral excretory pore somewhat nearer the cardiac than the median bulb; intestine rather thick-walled, three-fourths as wide as the body; rectum considerably longer than the anal body-diameter; tail concave-conoid; vulva inconspicuous; reflexed portions of the ovaries reaching half-way back to the vulva; eggs nearly as long as the body is wide and two-thirds as wide as long; viviparous or ovoviviparous; lateral pores near the middle of the tail. $\frac{3{\cdot}7 \quad 17{\cdot} \quad 27{\cdot} \quad `M^{57} \quad 94{\cdot}}{3{\cdot}3 \quad 4{\cdot}6 \quad 5{\cdot}3 \quad 3{\cdot}4 \quad 3{\cdot}}$ ·5 mm. Male tail conical, completely enveloped in the bursa, which springs from opposite the middle of the spicula; ribs of the bursa nine, in three similar rather indistinct groups because the spaces between the groups are not much greater than that between the individual ribs of a given group; anterior group just in front of the anus, posterior group near the end of the tail; spicula linear, tapering gradually from near the proximæ to an acute point, more than twice as long as the tail; proximæ cephalated by constriction. Detailed drawings are given on Pl. XXXVIII.

Hab.—Cosmopolitan; Europe, Australia, Fiji. I think there can be no doubt that this worm recorded now from Australia and Fiji is identical with Bütschli's species. I have found it on fresh grass and on dead sheaths of banana plants.

3. **R. australis**, n.sp. (?). $\dfrac{1\cdot \quad 12\cdot \quad 17\cdot \quad {}^{\backprime}55\cdot^{50} \quad 93\cdot2}{1\cdot5 \quad 3\cdot8 \quad 4\cdot3 \quad 4\cdot6 \quad 2\cdot4}$ 1·1 mm. Cuticula finely transversely striated; neck conoid, convex anteriorly; head somewhat pointed, truncate at the lips; lips six, conical, each with a setose papilla; pharynx simple, prismoid, tapering at the base, about one-third as wide as the head and more than twice as deep as wide; anterior three-fifths of the œsophagus cylindroid, about one-third as wide as the corresponding part of the neck; cardiac sucking bulb ellipsoidal, half as wide as the base of the neck, connected with the wider anterior three-fifths of the œsophagus by a tube one-fifth as wide as the corresponding part of the neck; intestine thin-walled, four-fifths as wide as the body; rectum as long as the anal body-diameter; ventral excretory pore just behind the nerve-ring; tail conical; vulva slightly elevated; vagina extending forward half-way to the cardiac region and containing spermatozoa near the flexure; ovary very long, reflexed and extending backward to near the anus; eggs ellipsoidal, as long as the body is wide and two-thirds as wide as long, thin-shelled, perhaps deposited before segmentation begins.

Hab.—Grass, Sydney, New South Wales, Australia.

4. **R. monhystera**, Bütschli. $\dfrac{2\cdot4 \quad 13\cdot \quad 20\cdot \quad {}^{\backprime}80\cdot^{40} \quad 90\cdot}{2\cdot4 \quad 4\cdot7 \quad 5\cdot4 \quad 5\cdot \quad 2\cdot4}$ ·7 mm. The cuticula of this cosmopolitan species is traversed by about four hundred transverse striæ. The posterior half of the neck is conoid, the anterior half convex-conoid. The truncate head, devoid of setæ, is surmounted by six spherical lips having a height equal to one-third the length of the pharynx, and each surmounted by a conspicuous projecting papilla. The simple cylindroid pharynx is about one-fourth as wide as long. The median œsophageal bulb is of about the same length as the pharynx and is one-half as wide as the neck; that portion of the œsophagus leading to it is a little more than one-third as wide as the neck, and that portion leading from it to the posterior bulb is a trifle narrower than that. The prolate posterior bulb is a little wider still than the median bulb and contains a distinct chitinous valvular apparatus. The cardiac collum is distinct. The ventral excretory pore is situated opposite the anterior part of the hindmost bulb. The oblique nerve-ring passes ventrally backward. The tail is conical to the pointed terminus. The lateral fields are one-fourth as wide as the body. The narrow reflexed ovary extends from one-fourth to one-half the distance back to the vulva. Passing round the bend the ova are fertilised and then develop in the uterus, those near the vulva being always more advanced than the others. $\dfrac{2\cdot6 \quad 15\cdot7 \quad 23\cdot4 \quad {}^{\backprime}M^{60} \quad 97\cdot}{3\cdot6 \quad 6\cdot1 \quad 6\cdot8 \quad 7\cdot7 \quad 3\cdot}$ ·9 mm. The tail of the male is conical and pointed; it is completely enveloped by the bursa, which begins opposite the proximal ends of the spicula. The ribs of the bursa are distributed in three groups: 1, a pre-anal group of two opposite the middle of the spicula; 2, a post-anal group of three occupying the anterior third of that part of the bursa behind the anus; 3, a post-anal group of three near the end of the tail. I saw on one specimen what appeared to be a ventral

papilla near the middle of the tail. The straight equal linear acute spicula are one and one-half times longer than the tail and are barely cephalated by expansion. The accessory piece is parallel to the spicula and is one-half as long as they. The reflexed portion of the testicle reaches one-fourth the distance back to the anus. The reader will do well to consult the drawings on Pl. xxxviii.

Hab.—Decaying leaves of banana plants, Fiji, July, 1891. These worms are common on fresh and living grass, and on celery in Australia.

5. **R. coronata,** n.sp. $\frac{6\cdot \quad 17\cdot \quad 26\cdot \quad {}^{\backprime}55^{\backprime 30} \quad 81\cdot}{4\cdot \quad 4\cdot 8 \quad 5\cdot 2 \quad 5\cdot 8 \quad 2\cdot 8}$ ·36 mm. is the formula for the only specimen seen. The cuticula was striated. The head was surmounted by six (?) conical lips each turned outwards. The cylindroid pharynx was about one-tenth as wide as long. The ellipsoidal median bulb was one-half as wide as the middle of the neck, and was situated half way between the mouth and the beginning of the intestine. The posterior bulb was of the same shape as the median, but was about half as wide again. Those portions of the œsophagus lying between the pharynx and the median bulb and between the median and posterior bulbs were equal in length but unequal in width, the latter being of the same width as the pharynx, while the former was twice as wide. The cardiac collum was distinct. The intestine was three-fourths as wide as the body. The ventral excretory pore was situated a little behind the nerve-ring. The latter was oblique, as is usual in *Rhabditis.* The tail was conoid to the middle, and thence to the hair-like terminus narrow. For further information consult Pl. xxxviii.

Hab.—In humus about the roots of banana plants, Fiji, July, 1891.

6. **Rhabditis** sp. (?). $\frac{3\cdot \quad 15\cdot 6 \quad 22\cdot 8 \quad ? \quad 85\cdot 6}{1\cdot 9 \quad 3\cdot 2 \quad 3\cdot 4 \quad 3\cdot 4 \quad 2\cdot}$ ·5 mm. Young worms having the foregoing dimensions were abundant between the sheaths of diseased banana plants sent from Fiji, July, 1891. The cuticula was traversed by numerous transverse striæ. The neck was conoid, the head truncate. There were six low lips on which no papillæ could be seen. The prismoid pharynx was one-eighth as wide as long. The anterior part of the œsophagus was one-half as wide as the neck, and to it succeeded an ellipsoidal median bulb, nearly two-thirds as wide as the neck; thence to the posterior bulb, which was of about the same size and shape as the median, the œsophagus was not above one-fourth as wide as the neck. The intestine was over two-thirds as wide as the body. The tail was conical. Further details with regard to this species will be found on Pl. xxxviii.

Genus MONHYSTERA, Bastian.

M. rustica, Bütschli. $\frac{\cdot 7 \quad ? \quad 18\cdot \quad {}^{\backprime}57^{26} \quad 75\cdot}{2\cdot 2 \quad ? \quad 4\cdot \quad 4\cdot 4 \quad 2\cdot 8}$ ·42 mm. The cuticle seems destitute of striæ. The nearly cylindroid neck terminates in a truncate head bearing near its margin six spreading setæ, arising opposite the base of the pharynx, each one-fourth as

long as the head is wide. There are six (?) indistinct papillæ inside the row of setæ. The circular lateral organs are one-fourth as wide as the neck, and are placed at a distance from the anterior extremity equal to four times the depth of the simple somewhat cup-shaped pharynx. This latter is one-third as wide as the head and leads into a cylindroid œsophagus nearly two-thirds as wide as the neck and presenting a very slight expansion in front of the distinct and deep cardiac constriction. For some distance behind the pharynx the œsophagus is very transparent. The lining of the œsophagus when seen in optical section is more or less sinuous. At the beginning, that is opposite the cardia, the intestine is somewhat transparent, giving rise at first to the impression that some gland-like organ is present here, but careful examination serves to dispel the deception. The intestine is two-thirds as wide as the body and is composed of cells indistinctly to be seen on account of the multitude of granules with which they are filled. The transparent rectum is conoid, and its length is equal to that of the anal body-diameter. Nothing was learned concerning either the ventral excretory organs or the lateral fields. The nerve-ring is situated near the middle of the neck. The tail is conoid to the terminus, where it is one-sixth as wide as at the base. The vulva is depressed. The eggs are twice as long as the body is wide and one-fourth as wide as long, and are probably deposited before segmentation begins. Illustrations on Pl. XXXVII.

Hab.—Found in humus about the roots of banana plants, Fiji, July, 1891, where it appeared to be uncommon. It is found also in Western Europe and many parts of Australia.

GENUS TRIPYLA, Bastian.

The comparatively simple and rudimentary Nematodes composing this genus have the proportions indicated by the generic formulæ $\frac{\cdot 0 \quad ? \quad 19\cdot \quad `53'^{28} \quad 86\cdot}{1\cdot 8 \quad ? \quad 3\cdot 2 \quad 3\cdot 6 \quad 2\cdot 7}$ 2·mm. and $\frac{\cdot 0 \quad 6\cdot 8 \quad 19\cdot \quad -M- \quad 85\cdot}{1\cdot 8 \quad 2\cdot 8 \quad 3\cdot 3 \quad 3\cdot 5 \quad 2\cdot 7}$ 2·mm. The species are usually found in moist or muddy soil, though one is marine. The cuticle is in most cases finely striated and destitute of any conspicuous hairs except the cephalic setæ, which apparently vary in number from six to ten and are invariably situated on the margin of the head, being in some cases so reduced in size as to resemble papillæ. The conoid neck ends in a head usually truncate and bearing three broad flat and inconspicuous lips armed with one or more inconspicuous papillæ. Nothing is known concerning the lateral organs; they must if present be very inconspicuous. There are no eye-spots. A pharynx is altogether absent, the mouth opening being on the surface of the head. The conoid to cylindroid œsophagus is sometimes slightly larger near the head; it is separated from the intestine, which is one-half to three-fourths as wide as the body, by a distinct constriction. The junction of the œsophagus with the intestine often forms a flat

bulb-like structure—pseudo-bulb. The rectum is short, seldom exceeding in length the anal body-diameter. Little is known concerning the ventral excretory gland; traces of it have been observed in but one species. In this respect, as well as in many others, this genus resembles *Monhystera.* The nerve-ring encircles the œsophagus squarely some distance in front of the middle of the neck. The tail has the same shape in both sexes, namely, conoid from the inconspicuous anus; the terminus, which is invariably a trifle swollen and often mucronate, gives exit to the secretions of the caudal glands,—always present. The female sexual organs are commonly double and symmetrically reflexed. What little evidence there is points toward the number of testicles being two (—M—). A ventral row of equidistant accessory sexual organs occurs on the male and extends forward from the anus sometimes to near the head. The two equal cuneiform spicula are straight or slightly curved and seldom exceed the anal body-diameter in length; they are accompanied by small accessory pieces. There is no bursa. Probably only a discovery of the males of the species *monhystera* (and possibly also of *arenicola)* can determine whether that species is really a member of this genus.

KEY TO TRIPYLA.

Cephalic setæ none, *i.e.*, reduced to papillæ.
- Length about 3· mm., head rounded.
  - Striæ coarse and conspicuous.......... 1. *salsa.*
  - Striæ fine and inconspicuous.......... 2. *papillata.*
- Length 1·4 mm. to 2·5 mm., head truncate.
  - When 1·4 mm. long read.......... 3. *affinis.*
  - When 2·5 m.m. long read.......... 4. *glomerans.*

Cephalic setæ present, not reduced to papillæ.
- Female sexual organs asymmetrical.
  - Vulva 64 %, tail 5 %.......... { 5. *arenicola.* 6. *minor.*
  - Vulva 78 %, tail 9 %.......... 7. *monhystera.*
- Female sexual organs symmetrical.
  - Habitat marine.......... 8. *marina.*
  - Habitat not marine.
    - Œsophagus 25 %.......... 9. *intermedia.*
    - Œsophagus little, if any, exceeding 20 %.
      - Tail occupying about 20 % of the length, conoid.......... 10. *filicaudata.*
      - Tail occupying about 15 % of the length, conoid.......... 11. *setifera.*
      - Tail occupying about 10 % of the length, anterior half only conoid... 12. *tenuicauda.*

KEY TO THE MALES.

Spicula shorter than the anal body-diameter.
- Habitat marine.......... 8. *marina.*
- Habitat not marine.......... 11. *setifera.*

Spicula longer than the anal body-diameter... 12. *tenuicauda.*
Spicula about equalling the anal body-diameter in length.
  Setæ none.
    Anterior extremity rounded.. 2. *papillata.*
    Anterior extremity truncate.
      Accessory pieces one-fourth as long as spicula.. 4. *glomerans.*
      Accessory pieces rudimentary... 3. *affinis.*
  Setæ 6.. 10. *filicaudata.*

Or,

Setæ 6-10.
  Habitat marine.. 6. *marina.*
  Habitat not marine.
    Spicula as long as the anal body-diameter, tail 22 %................................ 10. *filicaudata.*
    Spicula longer than the anal body-diameter, tail 9 %................................ 12. *tenuicauda.*
    Spicula shorter than the anal body-diameter, tail 16 %.............................. 11. *setifera.*
Setæ none.
  Accessory pieces one-fourth as long as the spicula .... 4. *glomerans.*
  Accessory pieces rudimentary.
    Length 3·2 mm., head rather rounded.. 2. *papillata.*
    Length 1·4 mm., head truncate... 3. *affinis.*

1. **T. salsa,** Bastian. $\frac{0 \quad ? \quad 17\cdot \quad \text{‘}50\cdot\text{’} \quad 87\cdot}{1\cdot7 \quad ? \quad 3\cdot2 \quad 3\cdot8 \quad 2\cdot8}$ 3·17 mm. The cuticle is marked by about three hundred and fifty transverse striæ. The head is rounded in front and bears two lateral papillæ. The œsophagus is cylindrical; the intestine is three-fifths as wide as the body; rectum half as long as the anal body-diameter. The junction of the œsophagus with the intestine is such as to give rise to the appearance of a "collar" or pseudo-bulb. The lateral fields are one-fifth as wide as the body. Terminus one-sixth as wide as the base of the tail. Male unknown.

Hab.—Found on roots of *Ruppia maritima,* in brackish water, England.

2. **T. papillata,** Bütschli. $\frac{0\cdot \quad 6\cdot7 \quad 18\cdot \quad \text{‘}55\cdot\text{’}^{26} \quad 86\cdot}{1\cdot6 \quad 2\cdot4 \quad 2\cdot7 \quad 2\cdot8 \quad 2\cdot1}$ 3·2 mm. Cuticula striated; head rounded in front, bearing three rows of papillæ, of which one represents the row of cephalic setæ; œsophagus conoid, anteriorly less but posteriorly more, than one-half as wide as the corresponding part of the neck; cardiac constriction exceedingly deep; tessellated intestine at first only one-fourth as wide as the body; rectum half as long as the anal body-diameter; juncture of the œsophagus with the intestine such that a very oblate pseudo-bulb is formed; terminus one-sixth as wide as the base of the tail; eggs as long as the body is wide; ovaries reaching about half-way back to the vulva. $\frac{0\cdot \quad 7\cdot \quad 18\cdot \quad M \quad 83.}{1\cdot6 \quad 2\cdot4 \quad 2\cdot7 \quad 2\cdot8 \quad 2\cdot1}$ 3·2 mm. Spicula equalling in length the anal body-diameter, with a central stiffening piece; accessory pieces rudimentary.

Hab.—Mud and moist earth, and among confervæ, Holland, and Frankfort, Germany.

3. **T. affinis**, de Man. $\frac{0\cdot \quad 8\cdot \quad 19\cdot \quad `52\cdot^{30} \quad 83\cdot}{2\cdot \quad 3\cdot \quad 3\cdot8 \quad 4\cdot1 \quad 2\cdot9}$ 1·4 mm. Cuticle marked by about four hundred transverse striæ; cephalic papillæ in three rows of six each, the middle row largest and representing the setæ; œsophagus conoid, in its narrowest part less than half as wide as the neck, with a distinct cephalic swelling; intestine tessellated, nearly two-thirds as wide as the body; rectum equalling the anal body-diameter in length; juncture of the œsophagus with the intestine forming a bulb-like swelling; terminus one-fifth as wide as the base of the tail; vagina half as long as the body is wide; eggs one and one-half times as long as the body is wide, and one-third as wide as long; ovaries extending two-thirds of the way back to the vulva. $\frac{0\cdot \quad 8\cdot \quad 19\cdot \quad M \quad 83\cdot}{2\cdot \quad 3\cdot \quad 3\cdot8 \quad 4\cdot1 \quad 2\cdot9}$ 1·4 mm. A ventral row of fourteen equidistant accessory organs extend from the anus to near the mouth; spicula elongated-cuneiform, nearly straight, rather acute, equal in length to the anal body-diameter; accessory pieces rudimentary.

Hab.—Found in moist marshes and meadows, Holland.

4. **T. glomerans**, Bastian. Female unknown. $\frac{0\cdot \quad ? \quad 21\cdot \quad M \quad 86\cdot}{2\cdot3 \quad ? \quad 4\cdot3 \quad 4\cdot3 \quad 3\cdot}$ 2·3 mm. Cuticle traversed by about six hundred and eighty transverse striæ; œsophagus cylindroid, half as wide as the neck; intestine three-fifths as wide as the body; pseudo-bulb flat; terminus one-seventh as wide as the base of the tail; spicula arcuate-cuneiform, slightly exceeding the anal body-diameter in length; accessory pieces one-fourth as long as the spicula.

Hab.—Mud of ponds, England.

5. **T. arenicola**, de Man. $\frac{0\cdot \quad ? \quad 17\cdot \quad `64\cdot^{13} \quad 95\cdot}{2\cdot \quad ? \quad 3\cdot \quad 3\cdot3 \quad 2\cdot4}$ 1·4 mm. Cuticle smooth; head truncate, bearing ten setæ arranged as usual, the submedian pairs unequal, the larger ones being half as long as the head is wide and very stout and acute; lips with a row of small papillæ in front of the setæ; œsophagus conoid, anteriorly one-third, but posteriorly one-half, as wide as the neck; intestine two-thirds as wide as the body, without distinct tessellation; rectum exceeding the anal body-diameter in length; pseudo-bulb present; tail ventrally arcuate; terminus narrow, rounded, mucronate; this and the following distinguished from the remaining species by the asymmetrical female sexual organs; ovary reaching three-fourths the way back to the vulva. Male unknown.

Hab.—Found in Holland.

6. **T. minor**, n.sp. $\frac{\cdot7 \quad 8\cdot3 \quad 20\cdot \quad `68\cdot^{26} \quad 94\cdot}{2\cdot5 \quad 3\cdot4 \quad 3\cdot6 \quad 3\cdot6 \quad 2\cdot2}$ 1·2 mm. Cuticle apparently without markings; hairs minute, if any; neck cylindroid; head truncate, bearing on its outer margin ten

spreading setæ arranged in the usual manner, four, *i.e.*, one of each submedian pair, being half as long as the others, these latter measuring one-half as long as the head is wide; lips three, each with two papillæ; lateral organs probably represented by small elliptical markings no wider than the base of the cephalic setæ and situated at a distance from the anterior extremity nearly equal to the width of the head; eyes none; pharynx infundibuliform, simple; œsophagus sub-cylindrical, one-third to three-fifths as wide as the neck, widest at the pharynx and posteriorly; cardiac collum distinct; intestine three-fourths as wide as the body, loosely granular and quite transparent; rectum two-thirds as long as the anal body-diameter; no ventral gland seen; nerve-ring encircling the œsophagus squarely, half as wide as the œsophagus at the point encircled; body diminishing suddenly in size near the anus; tail conoid to the middle, where it is one-third as wide as at the anus, thence more or less cylindroid to the conoid terminus, which contains a small outlet for the secretion of the caudal glands; anus depressed, more or less open; vulva not very prominent; eggs three to four times as long as the body is wide and one-fourth as wide as long; reflexed portion of the ovary reaching nearly to the vulva. Several drawings of this little worm will be found on Pl. XXXIX.

Hab.—Soil about banana plants, Fiji, July, 1891.

7. **T. monhystera**, de Man. $\frac{0\cdot \quad ? \quad 20\cdot \quad -78\cdot \quad 91\cdot}{1\cdot2 \quad ? \quad 2\cdot \quad 2\cdot \quad 1\cdot7}$ 1·8 mm. The smooth cuticle bears four sub-cephalic setæ behind the six slender cephalic setæ, the latter being half as long as the head is wide. The truncate head bears papillæ round the mouth. Lateral organs are perhaps present. The conoid œsophagus, which is a trifle enlarged in the anterior fourth, is posteriorly one-half, though anteriorly one-third, as wide as the neck. The intestine is three-fourths as wide as the body and ends in a rectum about as long as the anal body-diameter. The terminus is very narrow, but mucronate. The eggs are over three times as long as the body is wide and one-fifth as wide as long. The male is unknown.

Hab.—Marshy places, on the roots of plants, Holland, not common.

8. **T. marina**, Bütschli. $\frac{0\cdot \quad ? \quad 16\cdot \quad `50\cdot' \quad 90\cdot}{2\cdot3 \quad ? \quad 3\cdot9 \quad 4\cdot2 \quad 3\cdot6}$ 1·8 mm. Cuticle smooth; cephalic setæ six, nearly one-third as long as the head is wide; lumen or lining of the œsophagus widened behind the mouth; intestine half as wide as the body, thin-walled, with a large cardiac cavity; lateral, median and submedian fields present, the first perhaps half as wide as the body; anterior two-thirds of the tail convex-conoid, thence having a uniform diameter one-fifth as great as at the base; $\frac{0\cdot \quad ? \quad 16\cdot \quad M \quad 92\cdot}{2\cdot3 \quad ? \quad 3\cdot9 \quad ? \quad 3\cdot6}$ 1·8 mm. Spicula cuneiform, three-fifths as long as the anal body-diameter, slightly bent near the middle; accessory pieces small, quadrangular.

Hab.—Strand, Kiel, Germany. Perhaps not a *Tripyla*.

9. **T. intermedia,** Bütschli. $\frac{0\cdot \quad ? \quad 25\cdot \quad `53'^{28} \quad 84\cdot}{1\cdot6 \quad ? \quad 3\cdot6 \quad 4\cdot \quad 3\cdot}$ 1·mm. Head truncate, with six cephalic setæ, each about one-fourth as long as the head is wide, with a row of papillæ inside the setæ ; œsophagus conoid, half as wide as the neck ; intestine at once two-thirds as wide as the body ; rectum half as long as the anal body-diameter ; pseudo-bulb present, irregular ; vulva very prominent.

Hab.—Roots of grass, Frankfort-on-the-Main, Germany.

10. **T. filicaudata,** de Man. $\frac{0\cdot \quad ? \quad 18\cdot \quad `46\cdot'^{30} \quad 78\cdot}{1\cdot5 \quad ? \quad 2\cdot4 \quad 2\cdot8 \quad 1\cdot9}$ 2·mm. About eight hundred transverse striæ traverse the cuticula. The truncate head bears four submedian sub-cephalic setæ just behind the six stout acute cephalic setæ (the latter one-third as long as the head is wide), and two rows of papillæ round the mouth. The œsophagus is nearly cylindrical, being only slightly narrower in the middle than elsewhere. The tessellated intestine ends in a rectum two-thirds as long as the anal body-diameter. Pseudo-bulb present. The lateral fields are one-third as wide as the body. The tail is usually ventrally arcuate and ends in a terminus one-seventh as wide as its base. The vulva is prominent and projecting. The eggs are nearly as wide as the body and twice as long as wide. The ovaries extend one-third the distance back to the vulva. $\frac{0\cdot \quad ? \quad 20\cdot \quad M \quad 78\cdot}{1\cdot5 \quad ? \quad 2\cdot4 \quad 2\cdot8 \quad 1\cdot9}$ 1·7 mm. Fourteen or fifteen accessory organs form a ventral row reaching from the anus to near the mouth. The nearly straight cuneiform spicula equal the anal body-diameter in length and are stiffened by central pieces of chitin. There are no accessory pieces.

Hab.—Found in moist earth, Holland ; not common.

11. **T. setifera,** Bütschli. $\frac{0 \quad ? \quad 20\cdot \quad `57\cdot'^{31} \quad 84\cdot}{2\cdot \quad ? \quad 3\cdot \quad 3\cdot8 \quad 2\cdot5}$ 1·7 mm. Cuticle finely striated; head truncate, with six cephalic setæ, each nearly half as long as the head is wide, and a row of papillæ both inside and outside these setæ ; œsophagus conoid, anteriorly one-half, but posteriorly two-thirds as wide as the neck, hardly enlarged anteriorly ; intestine tessellated, two-thirds as wide as the body ; rectum nearly equalling the anal body-diameter in length ; pseudo-bulb present ; terminus one-fifth as wide as the base of the tail ; vulva projecting ; ovaries reaching nearly back to the vulva. $\frac{0\cdot \quad ? \quad 21\cdot \quad -M- \quad 84\cdot}{2\cdot \quad ? \quad 3\cdot5 \quad 3\cdot9 \quad 3\cdot4}$ 1·7 mm. Row of ventral accessory male organs extending forward to near the mouth ; spicula arcuate-cuneiform with a central stiffening piece, four-fifths as long as the anal body-diameter ; accessory pieces rudimentary ; blind end of the anterior testicle lying near the commencement of the middle third of the body.

Hab.—Marshy earth, Holland ; roots of a fungus, Germany.

12. **T. tenuicauda,** n.sp. Female unknown. $\frac{0\cdot \quad 5\cdot \quad 17\cdot \quad M \quad 91\cdot}{1\cdot2 \quad 2\cdot2 \quad 2\cdot8 \quad 2\cdot8 \quad 1\cdot7}$ 2·5 mm. The cuticle is smooth and bears very short papilla-like hairs throughout. The neck is rather convex-

conoid, especially anteriorly, where it ends in a rounded head which is truncate at the mouth. There are ten cephalic setæ arranged as usual, one of each of the submedian pairs being shorter, the others being about one-sixth as long as the head is wide. I could discover no papillæ. The conoid œsophagus is anteriorly one-half, posteriorly three-fifths as wide as the neck, being only very slightly enlarged near the head; its lining is not very distinctly to be seen. From the rather indistinct cardiac collum the intestine is at once three-fourths as wide as the body. The duct of the ventral gland ends in an ellipsoidal ampulla, and empties through a ventral pore at the commencement of the second fifth of the neck (3·6%). The lateral fields are one-fourth as wide as the body. The anterior half of the tail is concave-conoid, thence, however, it is uniformly one-fifteenth as wide as at the base. The three small elongated pyriform caudal glands lie just behind the anus. The ventral row of male accessory sexual organs is composed of *seven fascicles* equidistantly arranged, the posterior one being opposite the middle of the spicula and the whole row being considerably longer than the tail (14°/₀). The elongated spicula are of nearly uniform size, being slightly arcuate in the proximal halves; their length is half as great again as that of the anal body-diameter. There are probably two testicles arranged symmetrically.

Hab.—Mud of a brook, Sydney, New South Wales, Australia.

GENUS PRISMATOLAIMUS, de Man.

1. **P. intermedius**, Bütschli (?). $\frac{2{\cdot}2 \quad ? \quad 27{\cdot} \quad {\cdot}71{\cdot}^{20} \quad 76{\cdot}5\,(?)}{2{\cdot} \quad ? \quad 3{\cdot} \quad 2{\cdot}5 \quad 1{\cdot}9}$ ·5 mm. The cuticle is traversed by about four hundred transverse striæ. Minute and extremely inconspicuous hairs occur from place to place throughout the length of the body. The conoid neck terminates anteriorly in a truncate head, bearing near its margin six equal spreading setæ, each about two-thirds as long as the head is wide. The lips are low and indistinct, but appear to be three in number; they bore no papillæ that I could see. Neither eyes nor lateral organs were to be seen. The edges of the triquetrous pharynx are indicated by three longitudinal ribs; the main part is two-fifths as wide as the head and this is continued by a diminishing part through which it is connected with the œsophageal lumen. The œsophagus where it receives the pharynx is two-thirds as wide as the corresponding part of the neck; it soon diminishes however to one-half as wide as the neck, then gradually widens posteriorly until it becomes two-thirds as wide as the base of the neck. The granular intestine, which is two-fifths as wide as the body, is separated from the œsophagus by a deep, broad and very distinct constriction, opposite to which are two bodies whose function is unknown to me. I discovered nothing concerning the ventral gland, the longitudinal fields or

the nerve-ring. The cinctured tail is conoid to the terminus, where it is one-fifth as wide as at the anus. There appear to be no caudal glands. The eggs are two-thirds as long as the body is wide and two-thirds as wide as long. The reflexed portion of the ovary reaches two-fifths the way back to the vulva and contains upwards of a dozen developing ova which in the distal part are arranged in several rows. The male has not yet been seen. I have made a number of sketches of the anatomy of this species; these are reproduced on Pl. XXXIX.

Hab.—Soil about banana plants, Fiji, 1891, not common. I am not positive that this worm is the same as that first seen by Prof. Bütschli in Germany; however the resemblance is so great that I do not feel justified in applying a new name, especially as the male has yet to be seen.

2. **P. australis,** n.sp. $\frac{1{\cdot}2 \quad ? \quad 21{\cdot} \quad {\cdot}41{\cdot} \quad 68{\cdot}}{1{\cdot}5 \quad 2{\cdot}1 \quad 2{\cdot}3 \quad 2{\cdot}4 \quad 1{\cdot}5}$ 1·mm. The plain transverse striæ of the cuticle are easily resolvable with a moderate power. The hairs, which occur throughout the length of the animal, are very inconspicuous except on the tail. The cylindroid neck terminates in a truncate head bearing ten setæ, each about half as long as the head is wide and arranged as usual, the members of the submedian pairs being subequal. The larger of the cephalic setæ just mentioned are of peculiar form, the diameter of the hair suddenly decreasing near the tip, the effect being that the hair appears as if encased in a sheath. There are papillæ round the mouth. Small lateral organs appear to me to be placed about as far behind the base of the pharynx as the latter is behind the anterior extremity. Their nature I could not make out. The short prismoid pharynx is nearly half as wide as the head and is covered over by the lips. The cylindroid œsophagus is half as wide as the neck. The thick-walled granular intestine is two-thirds as wide as the body and is separated from the œsophagus by a distinct and deep constriction. The cardia is transparent and gives rise to a pseudo-bulb. The tail is conoid from the depressed anus but tapers more rapidly at first than towards the end. It appeared that tail glands were present, the terminus being narrow but convex-conoid as if furnishing an outlet for the secretion of caudal glands, and on that account such glands may be supposed to be present, though not seen. The eggs are two-thirds as wide as the body, and five times as long as wide, and are probably deposited before segmentation begins.

Hab.—Roots of plants, Moss Vale, New South Wales, Australia.

GENUS PLECTUS, Bastian.

P. insignis, n.sp. $\frac{4{\cdot}6 \quad 15{\cdot} \quad 26{\cdot} \quad 49{\cdot} \quad 87{\cdot}}{2{\cdot}8 \quad 3{\cdot} \quad 4{\cdot}2 \quad 4{\cdot}2 \quad 2{\cdot}7}$ ·66 mm. The cuticle is traversed by plain transverse striæ easily made out with a lens of medium power. Short hairs occur throughout the length of the worm. The neck is conoid,—somewhat convex conoid

near the truncate head. Half-way between the anterior extremity and the lateral organs occur six cephalic setæ, each one-third as long as the head is wide. The obscure lips are probably three in number. The lateral organs are unclosed circumferences, one-fourth as wide as the head, and are situated opposite the middle of the pharynx; regarded as spirals, the right is a left-handed spiral, and the left a right-handed spiral. The long two-chambered pharynx reaches half-way to the nerve-ring, only the anterior part being referred to in the above formula: the anterior half is a strongly-lined tube, wider at the mouth, namely, one-third as wide as the head; the posterior half somewhat resembles the remainder of the œsophageal tube. This latter is anteriorly one-third as wide as the neck, but posteriorly narrows to one-fourth as wide as the neck, and finally expands to form an elongated bulb three-fourths as wide as the base of the neck and containing a distinct valve. The transparent intestine, which is two-thirds as wide as the body and rather thin-walled, is separated from the œsophagus by a distinct constriction. The ventral excretory pore is situated opposite the oblique nerve-ring. The two wings of the cuticle found on each side of the body are separated from each other by a distance equal to one-seventh the diameter of the body. The tail is conoid and ends in an apiculate terminus one-third as wide as the anal body-diameter is long. Caudal glands as in other *Plecti.* The vulva is inconspicuous. The eggs are three-fourths as wide as the body and five times as long as wide; only one seen and that behind the vulva, unsegmented. The female sexual apparatus is possibly single and reflexed, extending first forward and then back past the vulva.

Hab.—About the roots of plants, Moss Vale, New South Wales, Australia.

GENUS CEPHALOBUS, Bastian.

1. **C. similis,** n.sp. Very likely a new genus may have to be created to receive this interesting little worm, which I found on lettuce from a Chinaman's garden. The only specimen seen, a young female, gave the following dimensions: $\frac{1{\cdot}6 \quad 15{\cdot}5 \quad 22{\cdot}4 \quad 51{\cdot} \quad 86{\cdot}}{2{\cdot}3 \quad 4{\cdot}4 \quad 4{\cdot}7 \quad 5{\cdot}6 \quad 2{\cdot}6}$ ·64 mm. Neck conoid; head truncate, bearing six large bluntly conical lips; pharynx deep and complicated, composed of three parts as follows: 1, the part alluded to in the formula as 1·6 $^{\circ}/_{\circ}$ deep, one-third as wide as the head, fully twice as deep as wide, tapering behind into 2, which is closed and surrounded with a separate muscular layer, but which however has not so great a diameter as 3, which is nearly twice as long as the two anterior parts taken together, more than half as wide as the corresponding part of the neck and contains a narrow elongated cavity in its anterior half; œsophagus of three parts, with the pharynx forming a structure of the same form as the œsophagus of *Rhabditis, i.e.*, the anterior three-fifths about half as wide as the neck and connected with the rather weak ellipsoidal cardiac bulb

by a tube one-fourth as wide as the part of the neck it traverses; ventral excretory pore opposite the nerve-ring; intestine thick-walled, with a distinct chitinous lining; rectum as long as the anal body-diameter; tail conical; vulva elevated; female sexual organs probably double and symmetrical.

Hab.—Lettuce, Sydney, N.S.W., Australia.

2. **C. infestans,** n.sp. Female unknown. $\frac{2{\cdot}7 \quad 15{\cdot} \quad 23{\cdot} \quad {}^{\backprime}\mathrm{M}^{56} \quad 92{\cdot}}{2{\cdot} \quad 3{\cdot}9 \quad 4{\cdot}4 \quad 4{\cdot}5 \quad 3{\cdot}}$ ·62 mm. The cuticle is not striated and is destitute of hairs. The conoid neck ends in a small truncate head with a slightly expanded lip-region. Neither setæ nor papillæ were seen on the head. The anterior half of the pharynx is triquetrous and about one-fourth as wide as the head, while the posterior half is much narrower. The cylindrical anterior half of the œsophagus is about one-third as wide as the corresponding part of the neck; the posterior half is at first very slender, less than half as wide as in the anterior part, but expands finally to form an ellipsoidal bulb half as wide as the base of the neck. There are no eyes. The intestine is three-fourths as wide as the body. The tail is conoid. The length of the two equal elongated arcuate acute spicula is equal to that of the anal body-diameter; the proximæ are cephalated by constriction. The two accessory pieces are more than half as long as the spicula and are arranged parallel to them. At least four pairs of submedian papillæ occur on the posterior part of the male: 1, a pair as far in front of the spicula as the heads of the latter are in front of the anus; 2, a pair opposite the anus; 3, a pair at the beginning of the central third of the tail; 4, a pair at the end of the second third of the tail, *i.e.*, as far behind the anus as the pre-anal pair is in front of it. The blind end of the single reflexed testicle lies as far behind the cardia as the latter is behind the lips; from thence it passes forward half-way to the cardia, then turns backward. The ejaculatory duct appears to be twice as long as the tail. Sketches of this worm occur on Pl. xxxix.

Hab.—Found in great numbers (young) among the sheaths of diseased banana plants, Fiji, July, 1891.

Genus AULOLAIMUS, de Man.

A. exilis, n.sp. $\frac{4{\cdot}5 \quad 7{\cdot}5 \quad 23{\cdot} \quad -46{\cdot}^{14} \quad 73{\cdot}}{1{\cdot}6 \quad 1{\cdot}9 \quad 2{\cdot}1 \quad 2{\cdot} \quad 1{\cdot}}$ 1·07 mm. I place this worm with some hesitation in Dr. de Man's genus *Aulolaimus* for reasons that will be plain on comparing the Fiji worm with that of Holland. The cuticle appeared to me entirely naked and destitute of striæ. The sub-cylindroid neck terminates in a convex-conoid head, whose truncate apex bears three (?) obscure lips without conspicuous papillæ. There are no eyes, and no lateral organs were seen. The cylindroid pharynx is on the

average one-fourth as wide as the head, and is continued as a lumen half as wide in the œsophagus proper. This latter is cylindroidal and a little more than half as wide as the neck. A rather weak cardiac bulb appears to exist; the cardiac collum and the bulb were less distinctly seen than would appear from the figures. The granular intestine is two-thirds as wide as the body. I discovered nothing concerning the ventral gland. The nerve-ring, which is placed far forward, makes but a slight angle with the œsophagus. The slightly ventrally arcuate tail is conoid in the anterior third, and thence is setaceous to the terminus, whose structure precludes its being the outlet of caudal glands; these latter, therefore, probably do not exist. The eggs are apparently as long as the body is wide and two-thirds as wide as long. Male not seen. Sketches of this worm occur on Pl. XXXVII.

Hab.—Found in soil about banana plants, Fiji, July, 1891; not common.

GENUS DORYLAIMUS, Bastian.

1. **D. exilis**, n.sp. $\frac{\cdot 3 \quad 6\cdot 3 \quad 26\cdot 9 \quad \cdot 55\cdot^{25} \quad 91\cdot 4}{1\cdot \quad 2\cdot \quad 2\cdot 2 \quad 2\cdot 4 \quad 1\cdot 3}$ 1·76 mm. No cuticular markings were noted on the two specimens examined. The neck retains the diameter of the body in the greater part of its length, but becomes convex-conoid in the anterior fourth. The truncate head bears six distinct lips, each of which is armed with the usual two papillæ; the lip-region is expanded and conspicuous. The well-developed spear slides in a close-fitting collar situated just behind the lip-region. The anterior part of the œsophagus is one-third as wide as the corresponding part of the neck; the expansion takes place rather suddenly somewhat in front of the middle, and thence to the intestine the œsophagus is nearly three-fourths as wide as the body, its central canal being unusually conspicuous on account of the refractive nature of its thick chitinous lining. The cardiac collum is very distinct. The somewhat dark-coloured intestine is three-fifths as wide as the body and is rather thick-walled. The narrow rectum is nearly twice as long as the anal body-diameter. The pre-rectal portion of the intestine is twice as long as the rectum. The tail is conoid, but diminishes more rapidly in the anterior fourth than elsewhere. The eggs are two and one-half times as long as the body is wide and about one-third as wide as long. $\frac{\cdot 4 \quad 7\cdot \quad 20\cdot \quad \text{—M—}^{25} \quad 98\cdot 5}{1\cdot \quad 2\cdot 2 \quad 2\cdot 4 \quad 2\cdot 7 \quad 2\cdot}$ 1·6 to 2 mm. I have little doubt that this is the male of this species, although I did not find the two sexes associated. The differences in structure are very slight, if any; possibly the pre-rectal portion of the intestine is a trifle longer in these males. The male tail is blunt and rounded, hemispherical-conoid, and about four (possibly more) papillæ are found upon it near the end, to which nerves are plainly seen to pass. A ventral row of about sixteen closely approximated innervated papillæ begins at a distance in front of the spicula equal to the length of the latter and extends forward to some-

what behind the anterior end of the pre-rectal portion of the intestine. Oblique copulatory lateral muscles occur, co-extensive with the pre-rectum. The elongated acute spicula are bent at the middle ; their length is one and one-third times that of the anal body-diameter. Figured on Pl. xl.

Hab.—Somewhat rare about the roots of banana plants in Fiji, July, 1891.

2. **D. obtusus**, n.sp. $\frac{4\cdot \quad 6\cdot \quad 24\cdot \quad 42\cdot \quad 98\cdot4}{4\cdot \quad 2\cdot \quad 2\cdot7 \quad 2\cdot8 \quad 1\cdot9}$ 1·52 mm. The transparent cuticle of this rather striking species is finely striated. The slightly convex-conoid neck terminates in a somewhat truncate head with six inconspicuous lips each bearing two papillæ in the usual position. The anterior part of the œsophagus is one-third as wide as the corresponding part of the neck and ends in a well developed spear; the posterior part, beginning suddenly somewhat in front of the middle, is fully twice as wide as the anterior part. The cardiac collum is distinct but not deep. The intestine is about two-thirds as wide as the body and the contents of its component cells are sometimes so arranged as to give it an irregularly segmented appearance. The rectum is about three-fourths as long as the anal body-diameter, while the pre-rectal portion of the intestine is from three to four times as long as the rectum. The tail is short and rounded, the cuticula being slightly thicker in the terminal part. Figured on Pl. xl.

Hab.—Common about the roots of banana plants, in Fiji, July, 1891. Notwithstanding careful search, no males were found. The females did not seem very active.

3. **D. longicollis**, n.sp. $\frac{\cdot4 \quad 6\cdot2 \quad 37\cdot \quad \cdot48\text{-}^{48} \quad 99\cdot}{\cdot6 \quad 2\cdot2 \quad 3\cdot6 \quad 3\cdot6 \quad 2\cdot}$ 2·96 mm. No markings were observed on the smooth and rather thick transparent cuticula. The neck is conoid and ends in a rounded head composed of two parts of about equal length, of which the anterior is much the narrower, and bears six quite rudimentary lips. Cephalic papillæ if present must be so inconspicuous as to have escaped careful search. The well developed spear is about as long as the head is wide and about one-ninth as wide as the head. The sinuous anterior third of the unusually long œsophagus is one-fourth as wide as the corresponding part of the neck; at the end of the anterior third the œsophagus becomes suddenly muscular and larger, that is to say, one-half as wide as the neck, and continues thus to the end where it is separated from the intestine by a distinct collum. In young specimens the œsophagus occupies more than half of the length of the body. The thin-walled intestine is two-thirds as wide as the body, its component cells being of such a size that about twelve side by side make up the circumference, and having their granular contents so disposed as to give rise to a rather distinct tessellation. The rectum equals the anal body-diameter in length. In young worms the pre-rectal portion of the intestine was about twice as long as the rectum; presumably the ratio is no greater in the adults. The lateral fields are

one-fourth as wide as the body. The tail is nearly hemispherical. From the inconspicuous vulva the vagina, which is one-half as long as the body is wide, leads into two long uteri, in either of which the eggs are arranged in several rows. The anterior uterus is so long that the flexure in the oviduct sometimes lies in front of the cardiac region,—something uncommon in free-living nematodes. Supposing the specimens observed to have been mature, the sub-spherical eggs had a diameter one-fourth as great as the diameter of the body. Figured on Pl. XLI.

Hab.—The young were common about the roots of banana plants in Fiji, July, 1891. But few adult females were seen, and no males.

4. **D. perfectus**, n.sp. $\frac{\cdot 4 \quad 7\cdot 6 \quad 25\cdot 6 \quad `54\cdot' \quad 98\cdot}{\cdot 1 \quad 4\cdot \quad\quad 4\cdot 3 \quad 4\cdot 8 \quad\quad 2\cdot}$ 2·58 mm. The cuticula is thick and transparent. The neck is conoid, becoming convex-conoid near the head, which is truncate and bears six distinct doubly-papillate lips of the usual form. The well developed spear is one-fifth as wide as the head and slides in a distinct close-fitting collar, situated just behind the lips. The anterior part of the œsophagus is only one-fourth as wide as the corresponding part of the neck, but at the middle it enlarges rather suddenly and becomes two-fifths as wide as the body, its component cells being of such a size that ten side by side make up a circumference, and having their granular contents so disposed as to give rise to a distinct polygonal tessellation. The rectum is twice as long as the anal body-diameter. The pre-rectal portion of the intestine is about four times as long as the anal body-diameter, or in the males, twice as long as the spicula. The intestine is three-fourths as wide as the body. In the neck at least two unicellular glands were observed; each of these was as long as the neck was wide and emptied laterally (or sublaterally) by means of an indistinct ampulla and short narrow distinct chitinous pore which plainly penetrated all the cuticular structures at a distance from the head equal to five per cent. of the length of the body. The vulva is not conspicuous. The eggs are one and one-half times as long as the body is wide, three-fifths as wide as long. $\frac{\cdot 2 \quad 8\cdot 7 \quad 20\cdot 3 \quad -\mathrm{M}-^{28} \quad 98\cdot 6}{\cdot 8 \quad 2\cdot 7 \quad 3\cdot 6 \quad 3\cdot 8 \quad\quad 2\cdot 1}$ 2·35 mm. The tail of the male, like that of the female, is rounded, and bears the four sub-median papillæ, also found in the female. A single ventral row of about twenty-three innervated closely approximated low papillæ are found opposite the ductus ejaculatorius, that is to say, begins just in front of the spicula and extends nearly to the anterior extremity of the pre-rectal portion of the intestine. One such papilla stands alone just in front of the anus. Seen in profile the spicula are boomerang-shaped. They are acute, and are stiffened anteriorly by a median thickening. The proximæ are not cephaloid. Accessory pieces are apparently wanting. The spicula are very likely exserted by means of muscles passing obliquely to the extremity of the tail. Oblique copulatory muscles are present throughout the region of the ductus. Figured on Plates XL. & XLI.

Hab.—The worms were very common in the soil about the roots of banana plants in Fiji, July, 1891. The males were especially common. Only one female was seen, so that I am not perfectly certain that the male and female here described together really belong to one and the same species.

5. **D. granuliferus**, n.sp. $\frac{\cdot 4 \quad 8\cdot 7 \quad 26\cdot \quad {}^{\cdot}51\cdot^{\cdot 22} \quad 96\cdot}{1\cdot 1 \quad 3\cdot \quad 3\cdot 8 \quad 4\cdot 3 \quad 2\cdot}$ 1·37 mm. The six lips are very distinct and each bears the usual two papillæ. The anterior part of the œsophagus is one-fourth as wide as the corresponding part of the neck and is surrounded in front of the nerve-ring by three elongated granular bodies which become conspicuous when the worm is immersed in weak osmic acid; behind the nerve-ring the œsophagus gradually expands until it becomes, in the posterior half, two-thirds as wide as the neck. The tessellated intestine is about two-thirds as wide as the body and is composed of cells of such a size that about twelve side by side make up the circumference. The narrow rectum is somewhat less than twice as long as the anal body-diameter, being about equal in length to the tail. The pre-rectal portion of the intestine is one and one-half times longer than the rectum. The lateral fields are one-third as wide as the body. The tail is pointed and decreases more rapidly in the anterior half than in the posterior half. The reflexed portions of the ovaries reach half-way back to the vulva. The eggs are a trifle longer than the body is wide and a little more than one-third as wide as long. Figured on Pl. XL.

Hab.—Not uncommon about the roots of banana plants in Fiji, July, 1891. No males were found.

6. **D. spiralis**, n.sp. $\frac{\cdot 16 \quad 4\cdot 4 \quad 15\cdot \quad {}^{\cdot}45\cdot^{\cdot 25} \quad 99\cdot 2}{\cdot 6 \quad 2\cdot \quad 2\cdot 2 \quad 2\cdot 7 \quad 1\cdot 5}$ 5·2 mm. The neck is cylindroid to near the nerve-ring; thence it is convex-conoid to the expanded lip-region. There are six distinct lips, and six papillæ, also distinct. The rather slender spear slides in a pharyngeal ring and can be clearly traced back a distance three times as great as the width of the head. The anterior third of the œsophagus is narrow;—it widens rather suddenly, so that the posterior two-thirds are three-fifths as wide as the corresponding part of the neck. The thin-walled tessellated intestine is three-fourths as wide as the body and is composed of cells of such a size that about sixteen are required to build up a circumference. The rectum is as long as the anal body-diameter; the pre-rectum is five times as long as the rectum. The lateral fields are at the neck one-eighth, and at the tail one-fourth, as wide as the body. The conoid-hemispherical tail seems to have a terminal pore and to contain a considerable number of small glands. The depressed vulva leads into a vagina one-half as long as the body is wide. The thick-shelled eggs are more or less ellipsoidal; they are three-fifths as wide as the body and twice as long as wide. The uteri seem to contain but one egg at a time, and this is probably deposited before segmentation begins. The ovaries reach two thirds to three-fourths the distance back to the vulva. Male unknown.

Hab.—Found among the bases of carrot leaves, Sydney, New South Wales, Australia, in July.

7. **D. domus Glauci**, n.sp. $\frac{\cdot 4 \quad 12\cdot \quad 28\cdot \quad `53\cdot'^{23} \quad 98\cdot 6}{1\cdot \quad 4\cdot 1 \quad 4\cdot 7 \quad 5\cdot 3 \quad 2\cdot}$ 1·98 mm. Neck conoid,– convex-conoid anteriorly; lips six, each with at least one distinct papilla; spear acute, well developed; œsophagus at first only one-fifth as wide as the corresponding part of the neck, but gradually and uniformly widening until it is at last more than half as wide as the base of the neck; rectum nearly twice as long as the anal body-diameter; pre-rectum three times the length of the rectum, tapering posteriorly; ovaries reaching two-thirds to three-fourths the way back to the vulva; eggs thick-shelled, ellipsoidal, as long as the body is wide and over half as wide as long.

Hab.—Found among moss on the walls of the Casa Poetæ, Pompeii, Italy. Possibly the widths given in the formula are too great.

8. **D. Vesuvianus**, n.sp. $\frac{\cdot 3 \quad 10\cdot 5 \quad 20\cdot \quad `47\cdot'^{40} \quad 98\cdot 3}{1\cdot 1 \quad 3\cdot 2 \quad 3\cdot 5 \quad 4\cdot 5 \quad 2\cdot 3}$ 1·15 mm. In the posterior part the neck is nearly cylindrical, but the anterior third is convex-conoid to the truncate head. The lip-region is not conspicuous, and the lips are either absent or very indistinct. There are perhaps two rows of papillæ, six in each row. The spear is very slender and can be traced backward only for a distance equalling one-fiftieth of the length of the worm. The anterior part of the œsophagus is only about one-fourth as wide as the corresponding part of the neck, but it expands suddenly behind the middle, so that the posterior third (male) or two-fifths (female) is twice as wide, *i.e.*, about half as wide as the base of the neck. The intestine is about half as wide as the body and is marked off from the œsophagus by a distinct constriction. The cardia is broad but not deep. The rectum is only three-fourths as long as the anal body-diameter; the pre-rectal portion of the intestine, however, is quite as long as the enlarged portion of the œsophagus. The lateral fields are nearly one-third as wide as the body. The tail in either sex is hemispherical or conoid-hemispherical. The inconspicuous vulva leads to a vagina half as long as the body is wide. The reflexed ovaries reach half-way back to the vulva. $\frac{\cdot 3 \quad 11\cdot \quad 25\cdot \quad \text{—M—} \quad 98\cdot 2}{1\cdot 3 \quad 3\cdot 7 \quad 4\cdot 2 \quad 4\cdot 5 \quad 2\cdot 5}$ 1· mm. A ventral row of eleven juxtaposed median innervated papillæ extends forward from opposite the proximal ends of the spicula. These latter are of the usual form and about twice as long as the tail. The internal male sexual organs occupy the posterior two-thirds of the body.

Hab.—Found among moss on the sides of Mount Vesuvius, Italy.

9. **D. labyrinthostoma**, n.sp. $\frac{1\cdot \quad 7\cdot \quad 29\cdot \quad `50\cdot' \quad 90\cdot}{1\cdot \quad 1\cdot 9 \quad 2\cdot 2 \quad 2\cdot 2 \quad 1\cdot 2}$ 1·75 mm. This species belongs to the group first made known through the researches of Dr. de Man, and characterised by the possession of elaborate mouth parts accessory to the spear. The group represents the acme of development in *Dorylaimus* so far as yet discovered. The spear presents

no very marked contrast with the spear as presented in other groups in the genus. The parts accessory to the spear may conveniently be arranged in two groups, (1) those serving to guide the spear in its forward and backward movements, and (2) those which line the lips and forward part of the pharynx, and serving, in my opinion, to give the animal a firm grip during the operations of piercing and sucking by which it gains its living. The principal part serving to guide the spear is a chitinous collar which is doubtless a further development of various similar but more simple contrivances found in all nematodes with a pharyngeal spear. In the present case this collar, which, were it not somewhat too flat, might be called bell-shaped, closely surrounds the spear at the base of the pharynx, being firmly held in place by horny processes anterior to it and partly constituting the interior wall of the pharynx. The parts lining the lips, and no doubt, as above stated, serving as biting organs, are less easily described. In the first place it is necessary to note that the lips and the lip-region are constructed externally much as in other *Dorylaimi*: there are six somewhat confluent lips each bearing two papillæ, the lip-region being expanded and the papillæ being arranged in two circles of six each, one circle inside the other but both situated near the margin of the head. Inside these lips and extending backward some little distance further is the pharynx, which is, roughly speaking, pyriform in shape, with the wider part foremost. Round the mouth-opening are ranged a number of processes, probably six, one from each lip, which appear to be capable of radial movement. Opposite the inner and anterior row of labial papillæ a row of numerous longitudinal ribs encircles the anterior part of the pharynx. The base of these ribs or teeth is a transverse ring larger than any other of its kind found in the head. What appears to be a repetition of this structure on a smaller scale and without the transverse ring occurs slightly further back, that is half-way between the mouth-opening and the spear-guide. The object of these complex structures is open only to conjecture, but I have little doubt that they are used as biting organs, or possibly as rasping surfaces in tearing down the cells of plants; I do *not* consider them organs of mastication. The examination of these mouth-parts and a comparison of them with those of *Onyx*, *Mononchus* and *Oncholaimus*, has convinced me that we have good ground for regarding the spear-bearing genera and what I may call the tooth-bearing genera (represented by *Mononchus*, *Oncholaimus* and other genera with a distinct dorsal tooth) as being related to each other and perhaps constituting a grand group. The further specific characters of *D. labyrinthostoma* are as follows: cuticle thick, destitute of markings and hairs; neck cylindrical posteriorly, convex-conoid anteriorly; head truncate; lateral organs not seen; eyes none; nerve-ring oblique; œsophagus anteriorly one-fourth as wide as the neck but widening gradually and becoming, near the middle, two-thirds as wide as the neck and so continuing to the end, where it is separated from the intestine by a distinct constriction; intestine three-fourths as wide as the body, its distinct pre-rectal part being twice as long as the body is wide;

rectum nearly twice as long as the anal body-diameter; tail conical and hair-fine at its terminus, without glands; anus and vulva not conspicuous. Male unknown. Figured on Pl. XXXVII.

Hab.—Soil about banana plants, Fiji, July, 1891, common.

GENUS TYLENCHOLAIMUS, de Man.

T. ensiculiferus, n.sp. $\frac{14\cdot4 \quad ? \quad 29\cdot \quad 34\cdot\text{'} \quad 98\cdot4}{2\cdot6 \quad ? \quad 2\cdot9 \quad 3\cdot \quad 2\cdot2}$ 1·75 mm. The thick transparent and naked cuticle seems not to be annulated. The neck is cylindroid in the posterior half and convex-conoid in the anterior half. The diameter of the head in the lip-region is equal to ·8 per cent. of the body-length, *i.e.*, is one-third as wide as the base of the spear. The head, somewhat rounded in front, bears no setæ and none but very inconspicuous lips, of which the number is probably three. There are no eyes. No lateral organs were seen. The pharynx, which is half as long and nearly one-third as wide as the neck, contains a spear whose three-bulbed base is one-fourth as wide as the middle of the neck and whose posterior third is three times thicker than the slender anterior two-thirds. From the base of the spear a narrow and, when the spear is not exserted, tortuous canal leads to the muscular much elongated cardiac bulb, which is twice as long as the neck is wide and fully four times as long as wide. The thick-walled granular intestine is one-half as wide as the body and is separated from the cardiac bulb by a deep and distinct constriction; the rectum is one-half as long as the anal body-diameter. The nature of the ventral gland, longitudinal fields, and nerve-ring remain unknown. The posterior end is rounded and thick-skinned, but its internal muscular matter ends in a blunt point. The male was not seen. Drawings of this interesting worm will be found on Pl. XLII.

Hab.—Found in soil about the roots of banana plants, Fiji, 1891. Not common.

GENUS TYLENCHUS, Bastian.

Transparent striated round worms, in most cases devoid of bristles or setæ, varying in length from one-third of a millimetre to three and a-half millimetres, attacking the tissues of plants, or more rarely animals, by means of a pharyngeal spear and sucking apparatus of the following construction: a three-bulbed spear, capable of being thrust forth and withdrawn by appropriate muscles, is connected with a powerful median œsophageal sucking-bulb by means of a tube whose lining is more chitinous than is usual in other Nematode genera; the median bulb is connected with a smaller posterior bulb of much weaker construction by means of a shorter and

weaker tube, which passes through the oblique nerve-ring, situated just behind the median bulb. The posterior bulb may become rudimentary, but probably never quite disappears. Lateral organs as well as visual organs are unknown in the genus. The female sexual apparatus is usually single and asymmetrical, being in that case usually straight and directed forward though often presenting a rudimentary posterior branch, but it may be double and symmetrical. In the former case the vulva is behind the middle; in the latter case it is central. The male possesses two equal slightly arcuate spicula and in most species a more or less well developed bursa.

1. **T. radicicola**, Greef. $\frac{3\cdot2 \quad 15\cdot \quad 17\cdot6 \quad Y \quad 87\cdot9}{2\cdot4 \quad 3\cdot3 \quad 3\cdot4 \quad 3\cdot6 \quad 2\cdot3}$ is the formula for the freshly hatched larva, of which the following is a further description:—Cuticle traversed by about five hundred transverse striæ; neck cylindroid to opposite the base of the buccal cavity, but thence to the mouth is convex-conoid; faint indications of lips; three-bulbed spear when at rest drawn back so that its apex is removed half the spear-length from the mouth; ellipsoidal sucking-bulb just in front of the nerve-ring; posterior œsophageal swelling weak and devoid of chitin; intestine pellucid, two-thirds as wide as the body, and having its cells closely packed with granules; ventral excretory pore just opposite the commencement of the intestine; lateral wings occupying an area one-fourth as wide as the body and presenting four parallel lines; tail conical from the inconspicuous anus; caudal glands absent, terminus pointed.

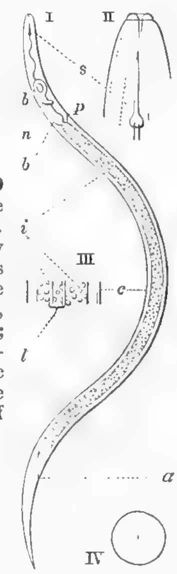


FIG. 4.—Larva of *Tylenchus radicicola.*

I, the larva magnified 190 times. II, head of the same worm magnified 875 times. III, small section of the body magnified 750 times. IV shows at the centre of the circle the actual size of the worm. *s*, spear; *b*, median sucking-bulb; *n*, nerve-ring; *p*, ventral excretory pore; posterior *b*, cardiac bulb; *i*, the intestine; *c*, the cuticle; *l*, the lateral wings of the cuticle.

The larvæ, which are found in large numbers in the cavities occupied by the parasitic mother-worms, and also in the surrounding soil, make their way into the rootlets of various plants by means of the special piercing and sucking apparatus, namely, the spear and bulb, and then undergo a remarkable metamorphosis. At an early moult they lose the conical tail and the posterior end becomes rounded. Meanwhile the body, amply nourished by plant-juices, becomes plump, and takes on the dimensions shown in the following formula and the adjacent illustrations: $\frac{4\cdot2 \quad ? \quad 17\cdot9 \quad Y \quad 91\cdot}{3\cdot8 \quad ? \quad 9\cdot5 \quad 16\cdot1 \quad 6\cdot}$ The larva makes its way into a rootlet by applying its mouth to the surface of the rootlet and exerting a powerful

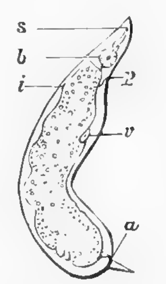


FIG. 5.—Young of *Tylenchus radicicola*, after entering a root.

s, spear; *b*, sucking-bulb; *p*, ventral excretory pore; *i*, intestine; *v*, unicellular ventral gland; *a*, anus.

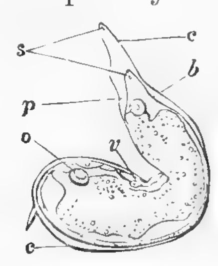


FIG. 6.—Immature *Tylenchus radicicola* shedding its skin.

c, the old skin being cast off; *s*, the old and the new spear; *p*, the ventral excretory pore; *v*, the unicellular ventral gland; *o*, rudimentary sexual organs.

suction by means of the sucking-bulb, at the same time thrusting forth its spear by means of the muscles attached to its three-bulbed base. The cells of the epidermis of the rootlet having been thus pierced are sucked dry, and at the aperture thus made other and deeper cells are similarly attacked. Continuing this line of action, the little worm makes its way into the rootlet, where its presence soon excites abnormal growth, resulting in galls, which vary in size, according to the species of plant attacked, from the size of a pin's head to that of a large walnut. In consequence of these attacks, many cultivated crops, as, for instance, potato, cabbage, banana, pea, bean, members of the melon family, beet, parsnip, radish, tomato, plum, apricot, peach, almond, grape, and many others suffer much or succumb altogether. The worm is a veritable pest in many parts of New South Wales, Queensland and Victoria.

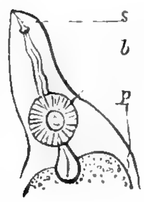


FIG. 7.—Neck of the worm shown in Fig. 5 more highly magnified.

s, spear; *b*, median sucking-bulb; *p*, ventral excretory pore.

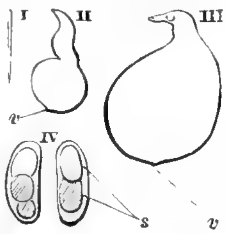


FIG. 8.—*Tylenchus radicicola.*

I, a young larva. II, a half-grown female. III, a full-grown female. IV, two eggs. *v*, the vulva; *s*, the segments of the egg after the first division. First three figures magnified twenty-five times, the others three hundred times.

Soon after the young worm loses its tail the sexual organs begin to develop. The female continues to grow stouter and finally becomes a flask-shaped sac devoid of anus and with a terminal vulva. The two-parted female sexual apparatus develops enormously, and at last almost completely fills the body-cavity, the eggs contained in it numbering several hundred. These undergo segmentation *in utero*, and are deposited (in the tissues of the attacked plant) containing already well-developed embryos.

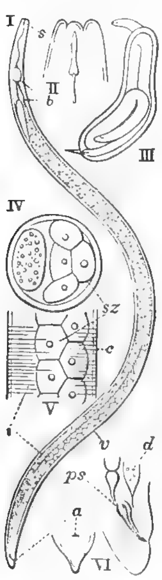


FIG. 9.—Male of *Tylenchus radicicola*

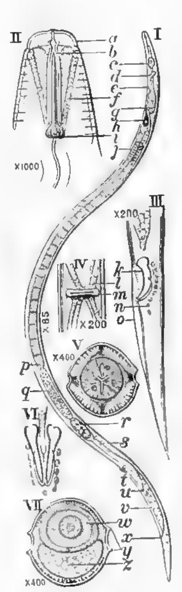
I, male worm magnified 60 times II, head of the same worm magnified 450 times. III, male shedding its skin for the last (?) time. IV, cross-section of the posterior part of the body. V, side view of the same part. VI, side and ventral views of the tail-end. *s*, spear; *b*, median sucking-bulb; *sz*, spermatozoa; *c*, cuticle; *i*, intestine; *v*, seminal vesicle; *d*, posterior end of the ejaculatory duct; *ps*, spicula or penes; *a*, anus.

The male worm, however, instead of continuing in the path of development followed by the female, *returns to a slender adult form*, having the following dimensions and characters:—$\frac{1\cdot\quad ?\quad 13\cdot\quad \mathrm{M}\quad 98\cdot7}{1\cdot2\quad 2\cdot2\quad 2\cdot3\quad 3\cdot\quad 1\cdot6}\ 1\cdot33\,\mathrm{mm.}$ Cuticula with about five hundred transverse striæ; neck conoid, head truncate; lips six, distinct; spear stout; œsophageal tube one-fourth as wide as the neck, lined with thick glistening chitin; median bulb ellipsoidal, two-fifths as wide as the neck, with a large distinct chitinous central part; intestine two-thirds as wide as the body, its cells closely packed with granules; rectum twice as long as the anal body-diameter; tail obliquely hemispherical-conoid; anus inconspicuous; bursa none; spicula acute, linear, nearly straight, wider and fusiform in

the proximal half, about twice as long as the tail or considerably longer than the anal body-diameter; no traces of accessory organs; ejaculatory duct at least three to four times as long as the spicula; spermatozoa large and spherical; lateral wings or projections three, closely approximate, giving rise to four longitudinal lines when the lateral view is interpreted by the microscope.

Hab.—Roots of cabbage, potato, banana, radish, pea, peanut, cow-pea, bean, squash, pumpkin, sanfoin, melon, cucumber, tomato, beet, plum, apricot, peach, almond, fig, walnut, willow, gourd, begonia, sunflower, amaranth, dahlia, purslane, egg-plant, spinach, maize, orange, grape, mulberry, morning-glory, petunia, spiræa, buddleia, shepherd's purse, blackberry, and probably numerous other plants, New South Wales, Queensland, and Victoria.

2. **T. devastatrix,** Kühn. $\frac{\cdot 9}{\cdot 8}\ \frac{8\cdot}{1\cdot 8}\ \frac{13\cdot}{2\cdot}\ \frac{81\cdot}{2\cdot 2}\ \frac{93\cdot}{1\cdot 2}$ 1·5 mm. The cuticle is traversed by about one thousand plain transverse striæ. The slightly convex-conoid neck terminates in a truncate head, the limits of whose lip-region are not easily made out. The lips are rudimentary, and there are no papillæ, unless they be represented by exceedingly minute projections immediately round the narrow mouth-opening. The well-developed spear is moved forward by three muscles passing obliquely from the three bulbs to the outer margin of the lip-region. The muscular ellipsoidal median bulb, lying just in front of the middle of the neck, has the same width as the head; its distinct three-chambered central cavity is thickly lined with chitin, which serves as the internal attachment of nucleated radial muscles. Somewhat behind the oblique nerve-ring the œsophageal tube begins to expand, and, continuing to do so to the end, thus forms a posterior bulb (fully one-fourth as long as the neck), which always contains about three large nuclei. These nuclei appear to me to indicate that this bulb or swelling is glandular rather than muscular in function. The intestine begins as an exceedingly fine tube leading backward from the œsophagus; it soon becomes three-fourths as wide as the body, and appears to be made up of two rows of cells packed with coarse granules. The limits of the rectum are indefinite, but it



a, lip-region.
b, tip of spear.
c, median sucking-bulb.
d, nerve-ring.
e, excretory pore.
f, muscles for moving the spear forward.
g, posterior œsophageal swelling.
h, excretory gland.
i, hind end of spear.
j, loop in ovary.
k, right spiculum or penis.
l, muscles for opening the vulva.
m, the vulva.
n, glandular (?) bodies.
o, bursa.
p, hind end of ovary.
q, uterus containing spermatozoa and one segmenting egg at *r*.
r, segmenting egg.
s, vagina.
t, the vulva or female sexual opening.
u, blind end of posterior rudimentary ovary.
v, intestine, showing its cellular structure.
w, cross-section of an egg.
x, anus.
y, wings of the cuticle.
z, cross-section of the intestine.

FIG. 9.—Side view of the devastating eel-worm.

I, a female worm. II, head of the same worm more highly magnified. III, tail of a male. IV, view from below, of the female sexual opening. V, cross-section of the worm passing through the sucking-bulb. VI, front view of the penes and their accessory parts. VII, cross-section through the middle of a female, showing how the body-cavity is filled completely by the ovary (*w*) and the intestine (*z*).

is not more than half as long as the anal body-diameter. The unicellular ventral gland lies just behind the œsophagus, and empties, by means of a slender tube devoid of an ampulla, through the ventral excretory pore, situated half-way between the nerve-ring and the posterior end of the œsophagus. The distance between the two lateral wings is equal to one-fourth the length of the diameter of the body. The median fields are very narrow; no submedian fields came under notice. The tail is conoid from the conspicuously-projecting vulva. The anus is inconspicuous. There are no anal glands. The vulva, a transverse slit one-half as long as the body is wide, is opened during copulation and oviposition by means of four pairs of oblique muscles arranged in two antagonistic groups, one anterior to the vulva and the other posterior. Each of the posterior pairs is attached distally near the ends of the slit and proximally to the body wall near the ventral submedian lines some distance back from the vulva. The antagonistic muscles are arranged similarly, but in front of the vulva. The short vagina leads forward into the uterus, which is as long as the distance from the vulva to the anus, and in adult worms commonly contains one or two eggs (three-fourths as wide as the body and twice as long as wide), which are in the later stages of segmentation. The anterior part of the uterus is occupied by numerous spermatozoa, which are placed there by copulation with a male, and which fertilise the egg immediately on its entry into the uterus. A rudimentary sac-like posterior branch of the sexual organ extends backward from the vulva half-way to the anus. The females are viviparous or ovoviviparous. $\frac{\cdot 9 \quad 8\cdot \quad 12\cdot \quad -\mathrm{M} \quad 93\cdot}{\cdot 8 \quad 1\cdot 7 \quad 1\cdot 9 \quad 2\cdot \quad 1\cdot 4}$ 1·4 mm. In the male the anus projects so as to be prominent. The transparent ribless bursa originates anteriorly opposite the proximal ends of the spicula, and ends behind the middle of the tail or near its end. The two equal elongated arcuate-cuneiform spicula are one and one-half times longer than the anal body-diameter, their proximæ being slightly cephaloid by expansion. The thin and inconspicuous accessory pieces, in which the spicula slide, are half as long as the spicula. In the neighbourhood of each spiculum and behind the anus I observed cells which may be glandular in function. The single testicle extends forward to near the œsophagus. The ripe spermatozoa are one-sixth as wide as the body.

Syn.—*T. dipsaci*, Kühn; *T. allii*, Beyerinck; *T. hyacinthi*, Prilleux; *T. Haversteinii*, Kühn.

Hab.—Parasitic in onions, hyacinths, teasel, rye, oats, buck-wheat, clover, potatoes, &c.

3. **T. granulosus**, n.sp. $\frac{2\cdot 8 \quad 10\cdot \quad 16\cdot \quad 56\cdot \quad 90\cdot}{2\cdot 3 \quad 2\cdot 7 \quad 2\cdot 8 \quad 3\cdot 3 \quad 2\cdot 4}$ ·68 mm. The cuticle is traversed by about four hundred and seventy-five transverse striæ, which exist in the outer as well as the inner layers. The conoid neck terminates anteriorly in a head somewhat rounded in front and bearing six somewhat spherical lips. The stout spear is one-tenth as

wide as the head, and the three bulbs at its base form a triple knot three times as wide as the shaft. Anteriorly the œsophagus is one-fourth as wide as the neck; somewhat behind the middle of the neck it expands to form a muscular prolate bulb one-half as wide as the neck. Thence it passes through the oblique nerve-ring situated just behind the bulb, and from being there one-fifth as wide as the neck it becomes rather suddenly one-half as wide as the neck, and joins the intestine in a rather indefinite manner at 16°/₀, as stated in the formula. The ventral excretory pore is situated at a distance behind the median bulb equal to thrice the length of that organ. The intestine is composed of cells containing coarse granules. The distance between the wings of the cuticle equals one-third the width of the body. The tail is conoid to near the terminus, where it diminishes suddenly to a blunt point. I saw only immature females, and cannot give details concerning the sexual organs. The above formula is the average of four specimens. Male unknown.

Hab.—Observed in numbers in brown rotten cavities three-fourths of an inch deep in the root-stock of banana plants, and also occasionally among the outer sheaths of the plants as well as in the adjacent soil, Fiji, 1891.

4. **T. similis**, n.sp. ―――――― Nearly all the information I have with regard to this species is set forth in the sketches on Pl. XLII

Hab.—Found about diseased banana plants, Fiji, July, 1891.

5. **T. multicinctus**, n.sp. $\frac{5\cdot \quad 16\cdot \quad ? \quad 66\cdot \quad 97\cdot}{2\cdot 9 \quad 3\cdot 5 \quad ? \quad 4\cdot 3 \quad 2\cdot 6}$ ·5 mm. Cuticula traversed by numerous plain transverse striæ, which are displayed in the outer as well as the inner layers; neck conoid; head somewhat rounded and presenting six transparent lips; spear well developed, stout, and with three prominent bulbs, in action guided by well-developed chitinous processes behind the lips; anterior part of the œsophagus a chitinous tube; median sucking-bulb considerably behind the middle of the œsophagus, ellipsoidal and presenting a well developed internal valve; nerve-ring oblique, close behind the median bulb; posterior part of the œsophagus at first tubular, but finally expanding into a swelling nearly half as wide as the base of the neck; intestine granular, two-thirds as wide as the body; tail convex-conoid, blunt; nature of the female sexual organs unknown. $\frac{5\cdot \quad 15\cdot \quad 22\cdot \quad -M \quad 97\cdot}{2\cdot 9 \quad 3\cdot 4 \quad 3\cdot 5 \quad 4\cdot \quad 2\cdot 3}$ ·5 mm. Spicula two, equal, elongate, tapering, acute, arcuate, proximal ends not cephalated, one and one-half times as long as the anal body-diameter; tail completely enveloped in the striated bursa which springs from opposite the proximal ends of the spicula and reaches its greatest development opposite the anus; accessory pieces half as long as the spicula and placed parallel to them. The worm is well figured on Pl. XLII.

Hab.—Found about the roots of banana plants, Fiji, July, 1891.

GENUS APHELENCHUS, Bastian.

Transparent striated round worms, nearly always totally devoid of bristles or setæ; varying in length from one-half a millimetre to one and a-half millimetres, attacking the tissues of plants by means of a spear and sucking apparatus of the following construction : a more or less distinctly three-bulbed spear, capable of being thrust forth and withdrawn by appropriate muscles, is connected with a powerful œsophageal sucking-bulb, by means of a tube whose lining is more chitinous than is usual in most Nematode genera. Behind the median bulb, the œsophagus continues for a short distance as a narrow tube, but soon gradually enlarges and joins the intestine in such a manner that it is often impossible to say where the œsophagus leaves off and the intestine begins. The oblique nerve-ring is situated just behind the sucking-bulb.

1. **A. microlaimus**, Cobb. $\frac{\cdot5}{\cdot7}\ \frac{4\cdot91}{1\cdot3}\ \frac{10\cdot3}{1\cdot7}\ \frac{-69-^{45}}{2\cdot2}\ \frac{95\cdot3}{1\cdot}$ ·7 mm. The cuticula is traversed by seven hundred transverse striæ. To the slightly convex-conoid neck succeeds a somewhat rounded head with six minute rudimentary lips, which are to be seen only in certain oblique aspects, and which are destitute of papillæ. The pharynx is armed with an unusually short spear, whose base presents three rudimentary bulbs. The œsophagus is one-fourth as wide as the neck and terminates posteriorly in an ellipsoidal bulb four-fifths as wide as the base of the neck ; thence the alimentary canal continues, at first narrow, but gradually widening. The bulb is, morphologically, probably the median bulb—the posterior part of the œsophagus being rudimentary and indistinguishable from the intestine. Nerve-fibres appear to exist both behind and in front of the bulb. The rectum seems to be about equal in length to the anal body-diameter. The ventral excretory pore is situated at a distance behind the œsophageal bulb equal to twice the length of the latter organ ; the gland of which it is the outlet is a very long and narrow cell as far behind the excretory pore as the latter is behind the mouth. The tail is conical to the terminus, which forms an outlet for the secretions of the caudal glands. The posterior branch of the sexual organs is only half as long as the anterior, and is therefore somewhat rudimentary.

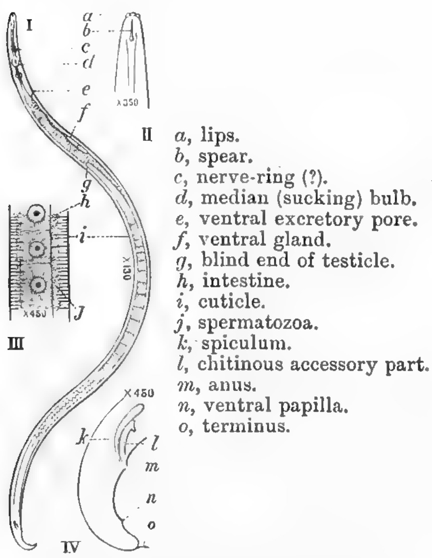


FIG. 10.—*Aphelenchus microlaimus.*

I, male worm. II, head of the same. III, portion of the middle of the body. IV, posterior extremity.

$\frac{\cdot9}{\cdot8}\ \frac{?}{1\cdot3}\ \frac{10\cdot5}{1\cdot7}\ \frac{-M^{68}}{2\cdot4}\ \frac{95\cdot1}{1\cdot7}$ ·66 mm. The ventrally-arcuate conoid tail of the male presents a

single median ventral papilla near the middle. The two linear acute spicula, half as long as the tail, are so close together that when seen in profile they appear as one. The proximal ends are not cephaloid. In front of the spicula is a structure one-half as long as the spicula themselves, concerning whose function I am uncertain. It may be accessory to the spicula, as it can be exserted at the same time. The blind end of the testicle is sometimes reflexed, and in it commences the development of the spermatozoa, which are arranged in single file through the organ.

Hab.—Common on grass, Sydney, N.S.W., Australia.

2. **A. longicaudatus,** n.sp. $\dfrac{2{\cdot}6 \quad 11{\cdot} \quad 10{\cdot} \quad -55{\cdot}^{40} \quad 70{\cdot}}{1{\cdot}6 \quad 1{\cdot}9 \quad 1{\cdot}8 \quad 2{\cdot}2 \quad 1{\cdot}1}$ ·8 mm. Cuticle apparently without markings; hairs none; neck conoid; cephalic setæ none; head truncate, the lip-region transparent; lips obscure, probably six; spear acute, slender, with inconspicuous posterior ending; œsophagus one-third to one-half as wide as the neck; bulb one-half to two-thirds as wide as the neck, twice as long as wide, or more, with a refracting chitinous central part; tail conical, in its posterior half setaceous; vulva inconspicuous; uterus with possibly a rudimentary posterior branch; eggs twice as long as the body is wide and one-third as wide as long, probably deposited before segmentation begins. $\dfrac{3{\cdot} \quad 14{\cdot} \quad 13{\cdot} \quad -M \quad 72{\cdot}}{1{\cdot}4 \quad 2{\cdot} \quad 2{\cdot} \quad 2{\cdot}6 \quad 1{\cdot}}$ ·57 mm. The male tail is like that of the female in form. There is no bursa or papilla or supplementary organ of any kind. The arcuate-cuneiform spicula are a little longer than the anal body-diameter, their proximal ends not being cephaloid. There is a chitinous structure in front of the spicula, possibly the chitinous terminal portion of the combined rectum and sexual opening, which is half as long as the spicula and expanded proximally much as in *A. microlaimus.* Figured on Pl. XLII.

Hab.—Soil about banana plants, Fiji, July, 1891. Not common.

3. **A. minor,** n.sp. $\dfrac{{\cdot}4 \quad ? \quad 12{\cdot} \quad -68{\cdot} \quad 92{\cdot}}{{\cdot}8 \quad ? \quad 2{\cdot}9 \quad 2{\cdot}8 \quad 1{\cdot}8}$ ·48 mm. Cuticle naked as usual, and with very fine markings, if any. The conoid neck ends in a truncate head with a definite lip-region. I am uncertain about the details of the pharynx. The prolate bulb contains a distinct valvular structure. The œsophageal tube is heavily lined with chitin. The intestine is coarsely granular. The ventral pore is situated somewhat behind the sucking-bulb. The conoid tail ends in what appears to be a conical outlet for the secretions of the caudal glands. The vulva is inconspicuous. The eggs are one-half as wide as the body and over twice as long as wide. Figured on Pl. XXXVIII.

Hab.—Found about the roots of banana plants, Fiji.

EXPLANATION OF PLATES.

PLATE XXXVI.

MONONCHUS DIGITURUS.

Fig. 1. Female worm. Fig. 2. Terminus of the tail. Fig. 3. Neck and head. Fig. 4. Tail.

a, spinneret; *b*, mouth-opening; *c*, papillæ; *d*, pharynx; *e*, two submedian teeth; *f*, single dorsal tooth; *g*, nerve-ring; *h*, œsophagus; *i*, vulva; *j*, anus; *k*, intestine; *l*, cardiac constriction.

MONONCHUS GYMNOLAIMUS.

Fig. 1. Female worm. Fig. 2. Head of the same worm more highly magnified. Fig. 3. Anal region.

a, papillæ round the mouth; *b*, papillæ on the margin of the head; *c*, rectum; *d*, lateral organ; *e*, striæ on wall of the pharynx; *f*, muscles of the pharynx; *g*, œsophagus; *h*, caudal glands; *i*, dorsal tooth; *j*, œsophagus; *k*, intestine; *l*, vulva and vagina; *m*, ovum, flexure in ovary; *n*, anus; *o*, excretory pore (?); *p*, cardiac collum; *q*, œsophagus.

MONONCHUS MINOR.

Fig. 1. Female worm. Fig. 2. Head of the same worm more highly magnified. Fig. 3. Neck and head. Fig. 4. Tail. Fig. 5. Portion of body.

a, papillæ on the margin of the head; *b*, papillæ round the mouth; *c*, dorsal tooth; *d*, rasp-like teeth on wall of the pharynx; *e*, beginning of the œsophagus; *f*, nerve-ring; *g*, anus; *h*, lateral field; *i*, vulva; *j*, egg; *k*, œsophagus.

RHABDITIS FILIFORMIS (?).

Fig. 1. Female worm. Fig. 2. Head. Fig. 3. Head. Fig. 4. Portion of the body.

a, pharynx; *b*, beginning of the œsophagus; *c*, œsophagus; *d*, cardiac bulb; *e*, flexure in ovary; *f*, blind end of ovary; *g*, vulva; *h*, blind end of ovary; *i*, posterior end of pharynx; *j*, anus; *k*, flexure in intestine; *l*, egg.

PLATE XXXVII.

AULOLAIMUS EXILIS.

Fig. 1. A female worm. Fig. 2. Head of the same worm. Fig. 3. Neck. Fig. 4. Cardiac region.

a, lips; *b*, pharynx; *c*, nerve-ring; *d*, base of pharynx; *e*, vulva; *f*, anus; *g*, œsophagus; *h*, cardiac bulb; *i*, cardiac bulb; *j*, beginning of the intestine.

CHROMADORA MINIMA.

Fig. 1. Neck. Fig. 2. Female worm.

a, cephalic setæ; *b*, pharynx; *c*, lateral organ; *d*, œsophagus; *e*, cardiac swelling; *f*, intestine; *g*, cardiac collum; *h*, vulva; *i*, anus; *j*, spinneret.

MONHYSTERA RUSTICA.

Fig. 1. Female worm. Fig. 2. Head and neck of the same worm.

a, cardiac collum; *b*, intestine: *c*, blind end of ovary; *d*, egg; *e*, vulva; *f*, anus; *g*, cephalic setæ; *h*, base of the pharynx; *i*, lateral organ; *j*, cardiac collum.

DORYLAIMUS LABYRINTHOSTOMA.

Fig. 1. A female worm. Fig. 2. Head of the same worm more highly magnified. Fig. 3. Part of the neck.

a, mouth-opening; *b*, one of the inner row of papillæ; *c*, one of the outer row of papillæ; *d*, row of rasping (?) organs; *e*, spear-guide; *f*, base of the spear; *g*, cardiac collum; *h*, vulva; *i*, pre-rectum; *j*, anus; *k*, nerve-ring; *l*, œsophagus.

CHROMADORA MUSÆ.

Fig. 1. An immature female worm. Fig. 2. Terminus of the tail. Fig. 3. Head.

a, cardiac bulb; *b*, nerve-ring; *c*, lateral organ; *d*, dorsal tooth; *e*, base of the pharynx; *f*, anus; *g*, œsophagus.

PLATE XXXVIII.

YOUNG RHABDITIS.

Fig. 1. Young worm. Fig. 2. Head and neck. Fig. 3. Head.

a, lips; *b*, pharynx; *c*, œsophagus; *d*, median bulb; *e*, nerve-ring; *f*, cardiac bulb; *g*, anus; *h*, nerve-ring.

APHELENCHUS MINOR.

Fig. 1. Anterior part of a female worm. Fig. 2. Tail. Fig. 3. Posterior part of a female worm.

a, tubular part of the œsophagus; *b*, median sucking-bulb; *c*, excretory pore; *d*, vulva; *e*, vulva; *f*, anus; *g*, spinneret.

RHABDITIS CORONATA.

Fig. 1. A female worm. Fig. 2. Head of the same worm more highly magnified.

a, lips; *b*, pharynx; *c*, median bulb; *d*, nerve-ring; *e*, cardiac bulb; *f*, cardiac collum; *g*, intestine; *h*, egg; *i*, vulva; *j*, egg; *k*, anus.

RHABDITIS MONHYSTERA.

Fig. 1. Female worm. Fig. 2. Male worm. Fig. 3. Tail of a male. Fig. 4. Head. Fig. 5. Tail of a female. Fig. 6. An egg with embryo.

a, blind end of ovary; *b*, egg; *c*, vulva; *d*, egg; *e*, flexure in ovary; *f*, anus; *g*, ductus ejaculatorius; *h*, spiculum; *i*, anterior group, ribs of bursa; *j*, median group, ribs of bursa; *k*, posterior group, ribs of bursa; *l*, pharynx; *m*, œsophagus; *n*, median bulb; *o*, nerve-ring; *p*, excretory pore; *q*, cardiac bulb; *r*, intestine; *s*, flexure in testicle; *t*, vas deferens; *u*, papillæ on lips; *v*, pharynx; *w*, rectum; *x*, lateral pores on tail of female; *y*, embryo.

RHABDITIS PELLIOIDES.

Fig. 1. A female worm. Fig. 2. Head. Fig. 3. Tail. Fig. 4. Small portion of the body. Fig. 5. Neck and head. Fig. 6. Tail of a male. Fig. 7. Tail of a male.

a, lips; *b*, pharynx; *c*, median bulb; *d*, nerve-ring; *e*, cardiac bulb; *f*, pharynx; *g*, papillæ; *h*, lip; *i*, anus; *j*, lateral wings; *k*, flexure in ovary; *l*, blind end of testicle; *m*, ribs of bursa; *n*, spermatozoa; *o*, bursa; *p*, egg; *q*, ribs of bursa; *r*, ribs of bursa; *s*, egg; *t*, vulva; *u*, anus; *v*, median bulb; *w*, ribs of bursa; *x*, excretory pore; *y*, ribs of bursa; *z*, ribs of bursa.

PLATE XXXIX.

TRIPYLA MINOR.

Fig. 1. Female worm. Fig. 2. Head of the same worm more highly magnified. Fig. 3. Tail of a female. Fig. 4. Tail of a female. Fig. 5. Tail of a female. Fig. 6. Front view of head. Fig. 7. Spinneret in the terminus of the tail. (Figs. 3, 4, 5 show difference in form and amount of motion.)

a, one of the papillæ round the mouth; *b*, one of the lateral setæ; *c*, one of the submedian setæ; *d*, supposed lateral organ; *e*, anus; *f*, spinneret opening; *g*, anus; *h*, anus; *i*, nerve-ring; *j*, cardiac collum; *k*, egg; *l*, vulva; *m*, lateral seta; *n*, one of the pairs of submedian setæ; *o*, anus; *p*, pharynx.

PRISMATOLAIMUS INTERMEDIUS.

Fig. 1. Female worm. Fig. 2. Head of the same worm more highly magnified. Fig. 3. Cardiac region showing structures (?) of unknown significance. Fig. 4. Portion of the female near the vulva. Fig. 5. Anal region. Fig. 6. Tail. Fig. 7. Terminus of tail. Fig. 8. Portion of body drawn to show striations and intestine.

a, cephalic setæ; *b*, pharynx; *c*, œsophagus; *d*, ovum; *e*, rectum; *f*, vulva; *g*, anus; *h*, posterior end of the œsophagus; *i*, structures of unknown significance; *j*, beginning of the intestine; *k*, blind end of ovary; *l*, vulva; *m*, terminus.

DIPLOGASTER PARVUS.

Fig. 1. Female worm. Fig. 2. Neck and head of another worm. Fig. 3. Head of female shown in Fig. 1. Fig. 4. Side view of body. Fig. 5. Anal region of a male.

a, pharynx; *b*, dorsal tooth; *c*, lateral field; *d*, median bulb; *e*, lips; *f*, dorsal tooth; *g*, pharynx; *h*, cardiac bulb; *i*, flexure of the ovary; *j*, blind end of ovary; *k*, vulva; *l*, anus; *m*, median bulb; *n*, nerve-ring; *o*, cardiac bulb; *p*, intestine; *q*, male papilla; *r*, male papilla; *s*, male papilla; *t*, male papilla; *u*, male papilla; *v*, left spiculum; *w*, accessory piece.

Cephalobus infestans.

Fig. 1. Male worm. Fig. 2. Tail of same worm more highly magnified. Fig. 3. Anal region of a male. Fig. 4. Neck and head.

a, male papilla; *b*, male papilla; *c*, male papilla; *d*, male papilla; *e*, left spiculum; *f*, accessory piece; *g*, lips; *h*, base of the pharynx; *i*, nerve-ring; *j*, cardiac bulb; *k*, intestine; *l*, flexure in testicle.

Plate XL.

Dorylaimus exilis.

Fig. 1. A female worm. Fig. 2. Tail of the same worm more highly magnified. Fig. 3. Cardiac region. Fig. 4. Head. Fig. 5. An egg.

a, pre-rectum; *b*, rectum; *c*, anus; *d*, lips; *e*, spear; *f*, nerve-ring; *g*, vulva; *h*, œsophagus; *i*, beginning of the intestine.

Dorylaimus granuliferus.

Fig. 1. A female worm. Fig. 2. Tail. Fig. 3. Cardiac region. Fig. 4. Head. Fig. 5. Portion of the body.

a, tip of the spear; *b*, papilla of the inner row; *c*, papilla of the outer row; *d*, papilla of the outer row; *e*, intestine; *f*, lateral field; *g*, nerve-ring; *h*, cardiac collum; *i*, flexure in anterior ovary; *j*, egg; *k*, vulva; *l*, blind end posterior ovary; *m*, pre-rectum; *n*, anus; *o*, œsophagus near posterior end; *p*, beginning of intestine; *q*, rectum; *r*, anus.

Dorylaimus obtusus.

Fig. 1. Young female worm. Fig. 2. Tail. Fig. 3. Head and anterior part of the neck. Fig. 4. Tail. Fig. 5. Head.

a, spear; *b*, lips; *c*, pre-rectum; *d*, anus; *e*, intestine; *f*, pre-rectum; *g*, anus; *h*, nerve-ring; *i*, nerve-ring; *j*, immature female sexual organs; *k*, anus; *l*, œsophagus.

Dorylaimus perfectus (?).

Fig. 1. Female worm. Fig. 2. Head and neck of the same worm. Fig. 3. Tail. Fig. 4. Head.

a, tip of the spear; *b*, one of the inner row of papillæ; *c*, one of the outer row of papillæ; *d*, base of the lips; *e*, nerve-ring; *f*, intestine; *g*, pre-rectum; *h*, egg; *i*, vulva; *j*, anus.

Plate XLI.

Dorylaimus perfectus.

Fig. 1. Male worm. Fig. 2. Anterior part of the neck of the same worm. Fig. 3. Tail end of the male shown in Fig. 1. Fig. 4. Anal region. Fig. 5. Spiculum. Fig. 6. Portion of intestine.

a, nerve-ring; *b*, œsophagus; *c*, intestine; *d*, intestine; *e*, blind end of anterior testicle; *f*, pre-rectum; *g*, left spiculum; *h*, anus; *i*, blind end of posterior testicle; *j*, anus; *k*, papillæ; *l*, junction of the testicles; *m*, spear; *n*, guiding-collar for spear; *o*, intestine; *p*, ventral row male papillæ; *q*, pore; *r*, papillæ; *s*, gland; *t*, nerve-ring; *u*, spiculum; *v*, oblique copulatory muscles; *w*, oblique copulatory muscles; *x*, œsophagus where it enlarges; *y*, tessellation of the intestine; *z*, a spiculum.

DORYLAIMUS LONGICOLLIS.

Fig. 1. A young worm. Fig. 2. Female, nearly adult. Fig. 3. Head and anterior part of the neck. Fig. 4. Tail. Fig. 5. Vulva and vagina. Fig. 6. Portion of the body.

a, nerve-ring; *b*, œsophagus; *c*, anus; *d*, anus; *e*, blind end of ovary; *f*, vulva; *g*, nerve-ring; *h*, cardiac collum; *i*, anus; *j*, pre-rectum; *k*, intestine; *l*, lateral field; *m*, vagina; *n*, vulva; *o*, lips; *p*, spear; *q*, nerve-ring; *r*, œsophagus where it enlarges.

PLATE XLII.

APHELENCHUS LONGICAUDATUS.

Fig. 1. A female worm. Fig. 2. Anal region of a male. Fig. 3. Head and neck. Fig. 4. Region of the vulva.

a, lips; *b*, base of spear; *c*, bulb; *d*, excretory pore; *e*, bulb; *f*, excretory pore; *g*, nerve-ring; *h*, right spiculum; *i*, accessory organ; *j*, anus; *k*, egg; *l*, vulva; *m*, anus; *n*, egg; *o*, vulva.

TYLENCHUS SIMILIS.

Fig. 1. Head and neck. Fig. 2. Portion of the body. Fig. 3. Tail of a male. Fig. 4. Male worm. Fig. 5. Anal region of a male.

a, spear; *b*, bulb; *c*, excretory pore; *d*, striæ; *e*, intestine; *f*, bursa; *g*, spicula; *h*, bursa; *i*, tips of the spicula.

TYLENCHOLAIMUS ENSICULIFERUS.

Fig. 1. Immature female. Fig. 2. Posterior part of the neck. Fig. 3. Anterior part of the neck. Fig. 4. Tail.

a, tip of the spear; *b*, narrow part of the shaft of spear; *c*, wider part of the shaft of spear; *d*, base of the spear; *e*, base of the spear; *f*, tube leading to bulb; *g*, bulb; *h*, intestine.

TYLENCHUS MULTICINCTUS.

Fig. 1. A male worm. Fig. 2. Neck and head. Fig. 3. Small portion of the body. Fig. 4. Head. Fig. 5. Tail of a male. Fig. 6. Tail of a male. Fig. 7. Tail of a female.

a, spear-guide; *b*, base of spear; *c*, chitinous tube leading to bulb; *d*, median bulb; *e*, nerve-ring; *f*, excretory pore; *g*, cardiac bulb; *h*, intestine; *i*, proximal ends of spicula; *j*, shaft of spiculum; *k*, accessory piece; *l*, lateral wings; *m*, bursa; *n*, anus; *o*, proximæ of spicula; *p*, points of spicula; *q*, bursa.

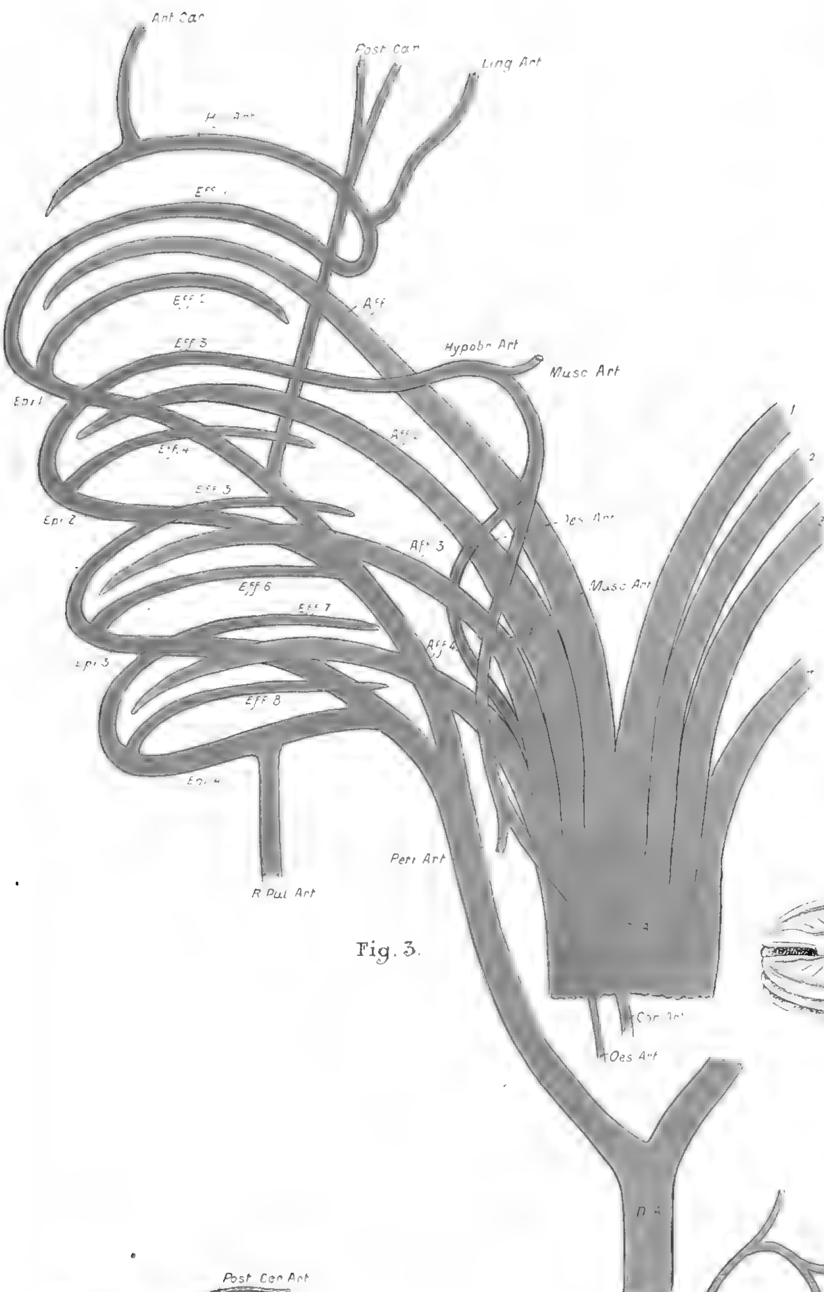


Fig. 3.

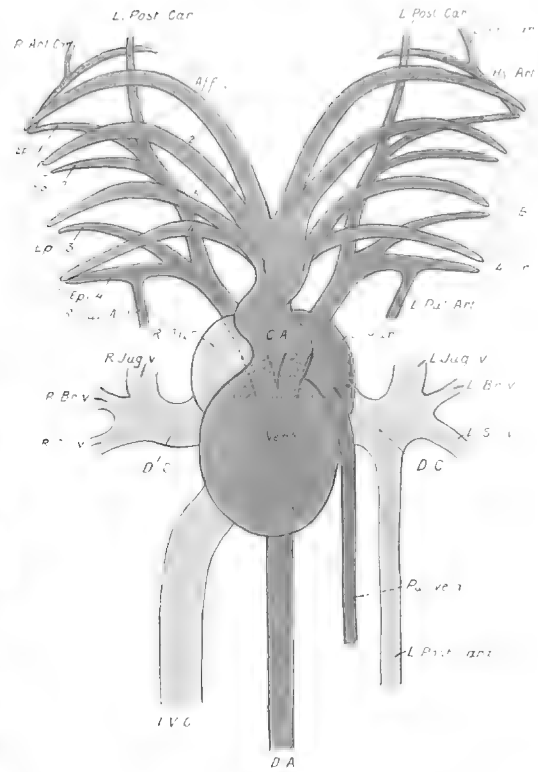


Fig 1

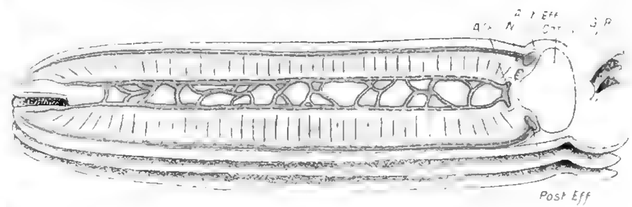


Fig. 4.

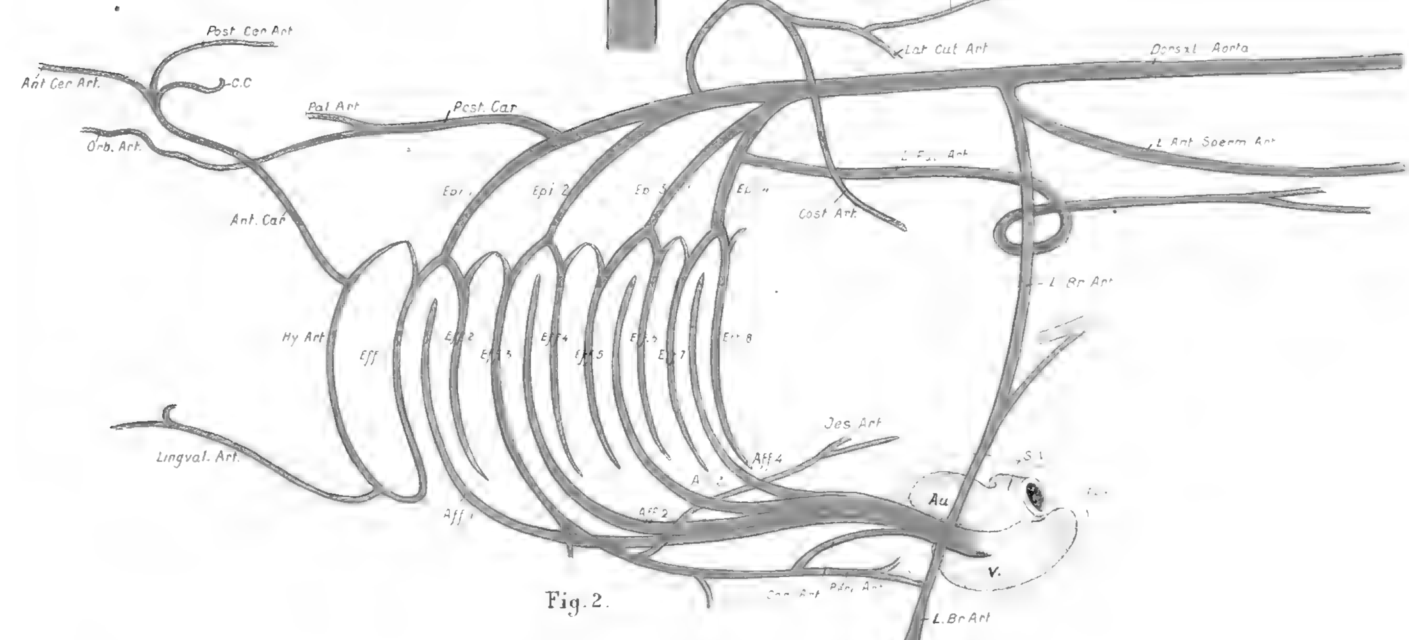


Fig. 2.

W B. Spencer del.

R Wendel lith. C Troedel & Co print

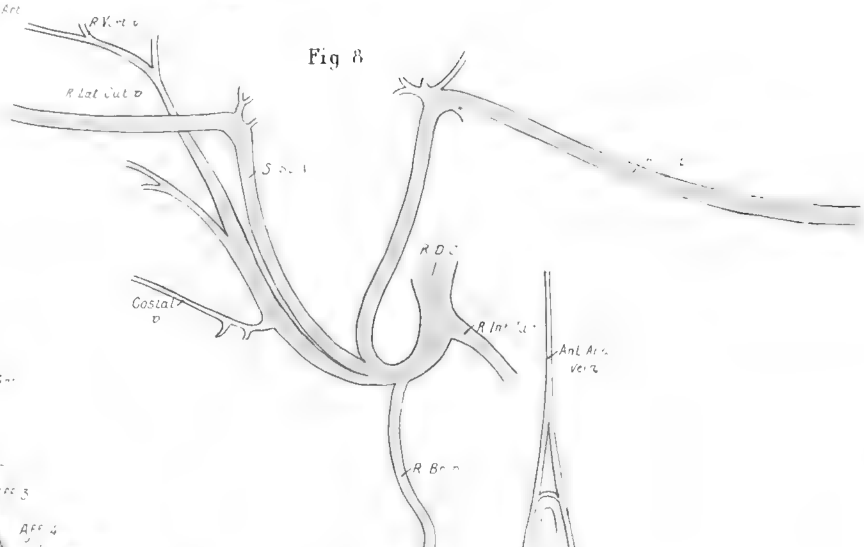


Fig 8.

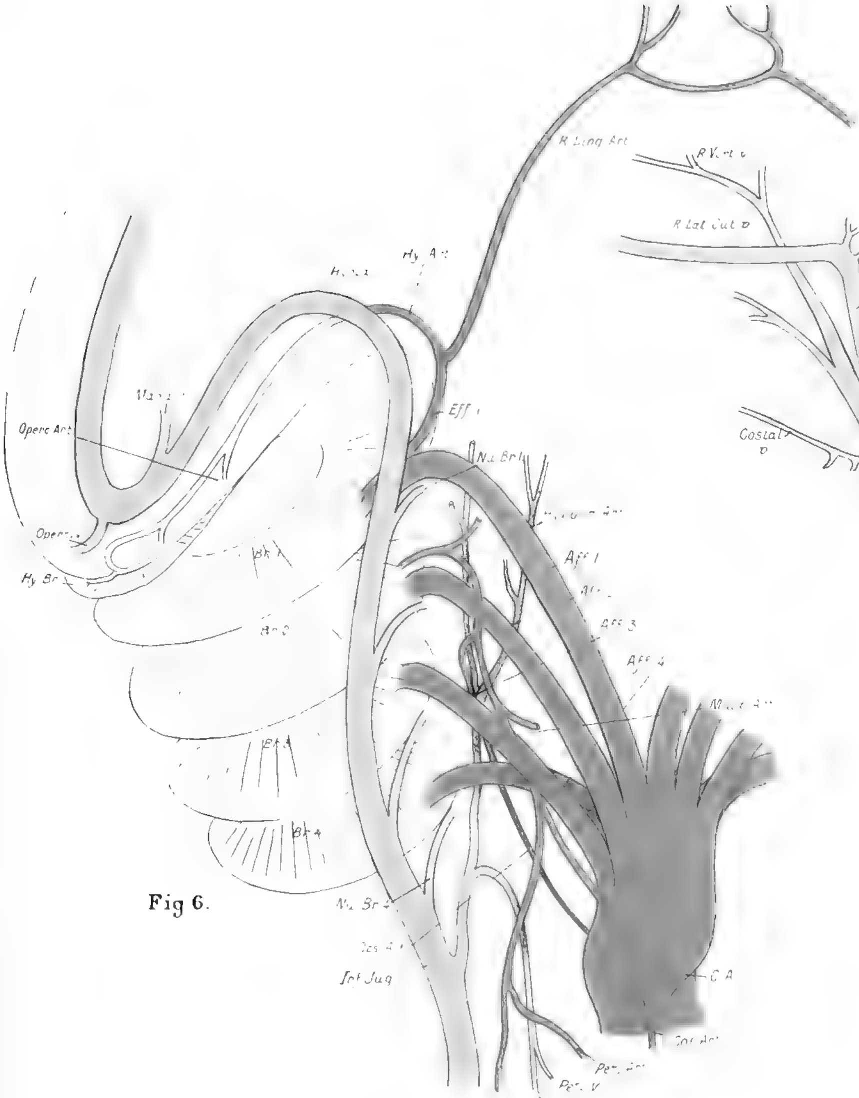


Fig 6.

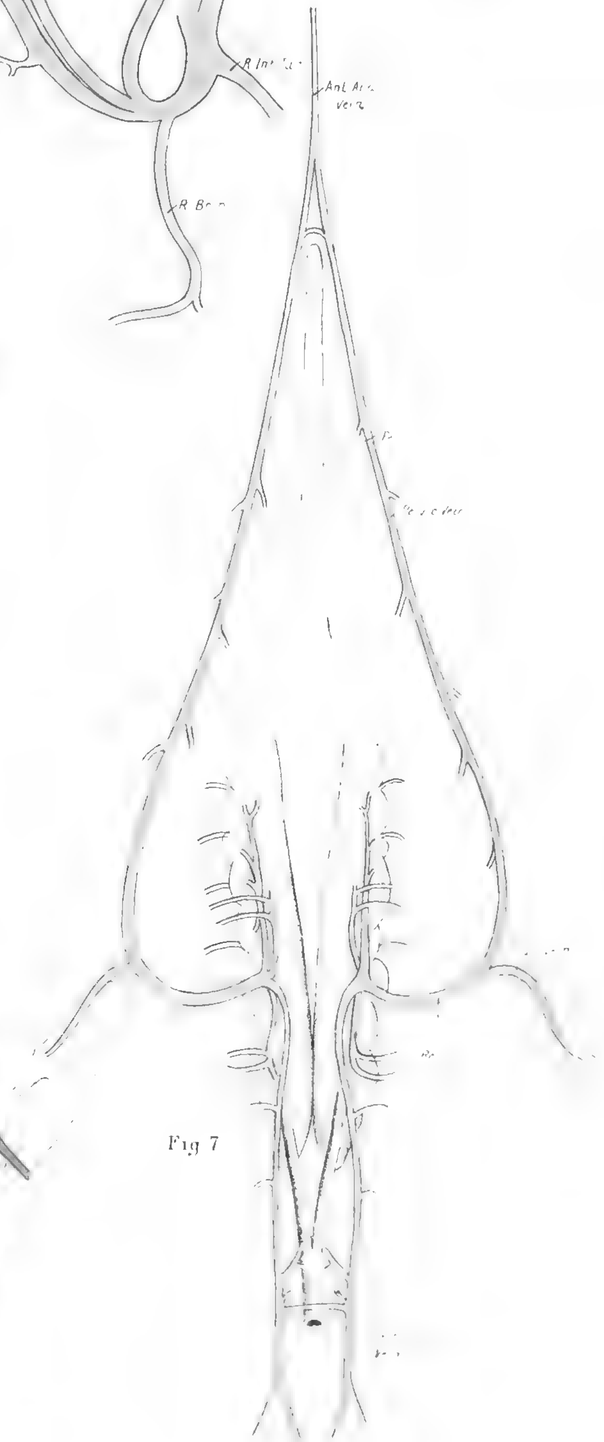


Fig 7

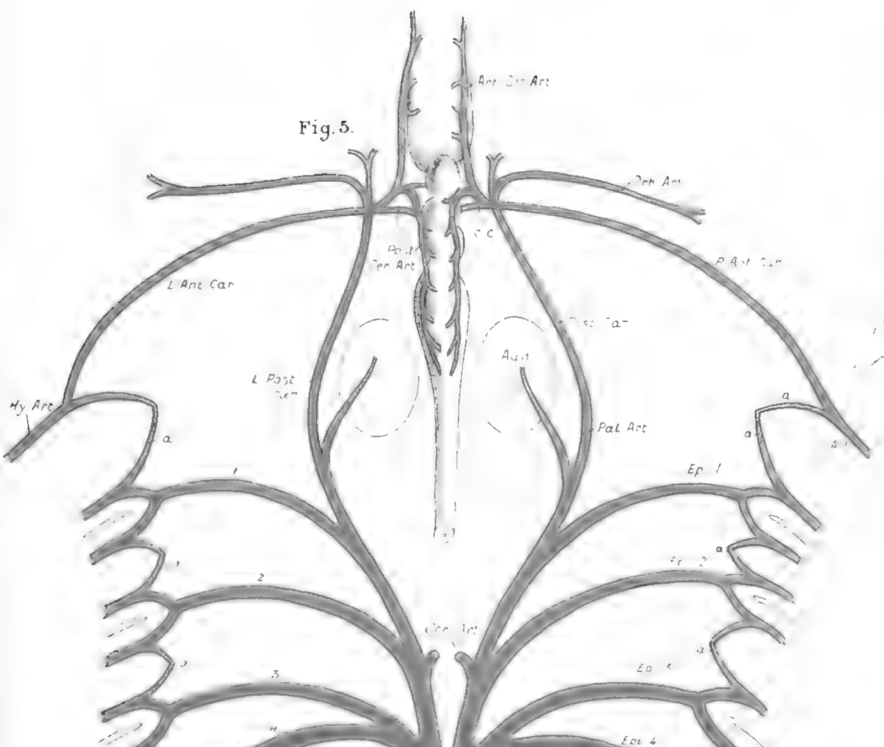


Fig. 5.

W. B. Spencer del.

R. Wendel lith. C. Troedel & Co print

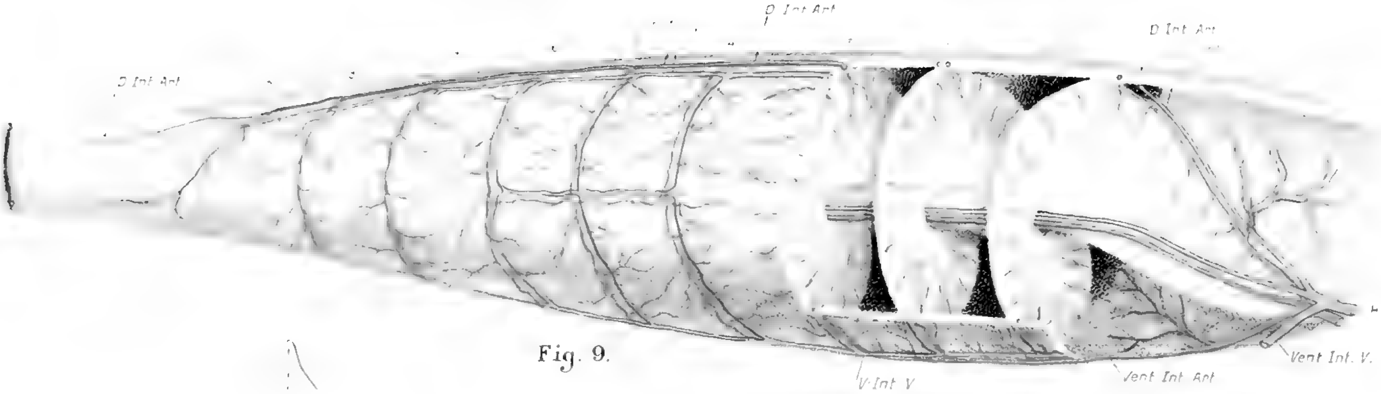


Fig. 9.

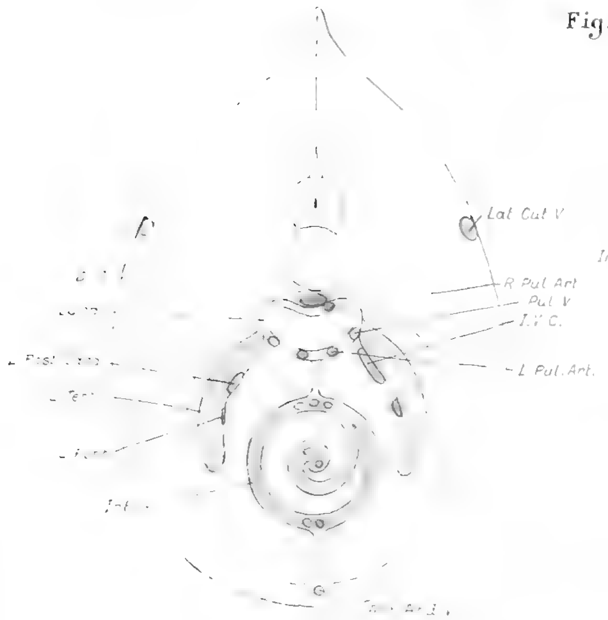


Fig. 13.

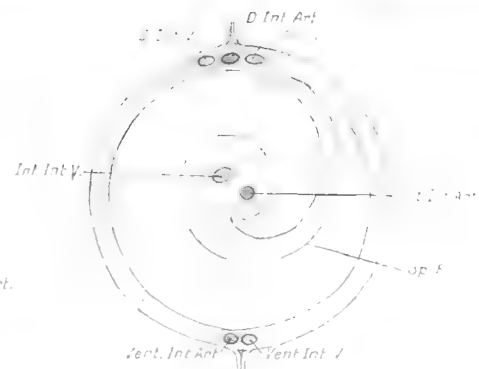


Fig. 12.

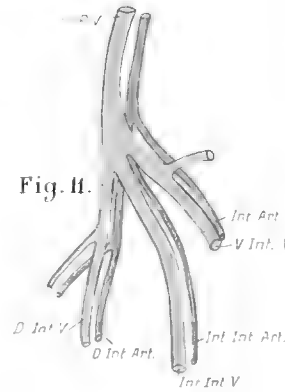


Fig. 11.

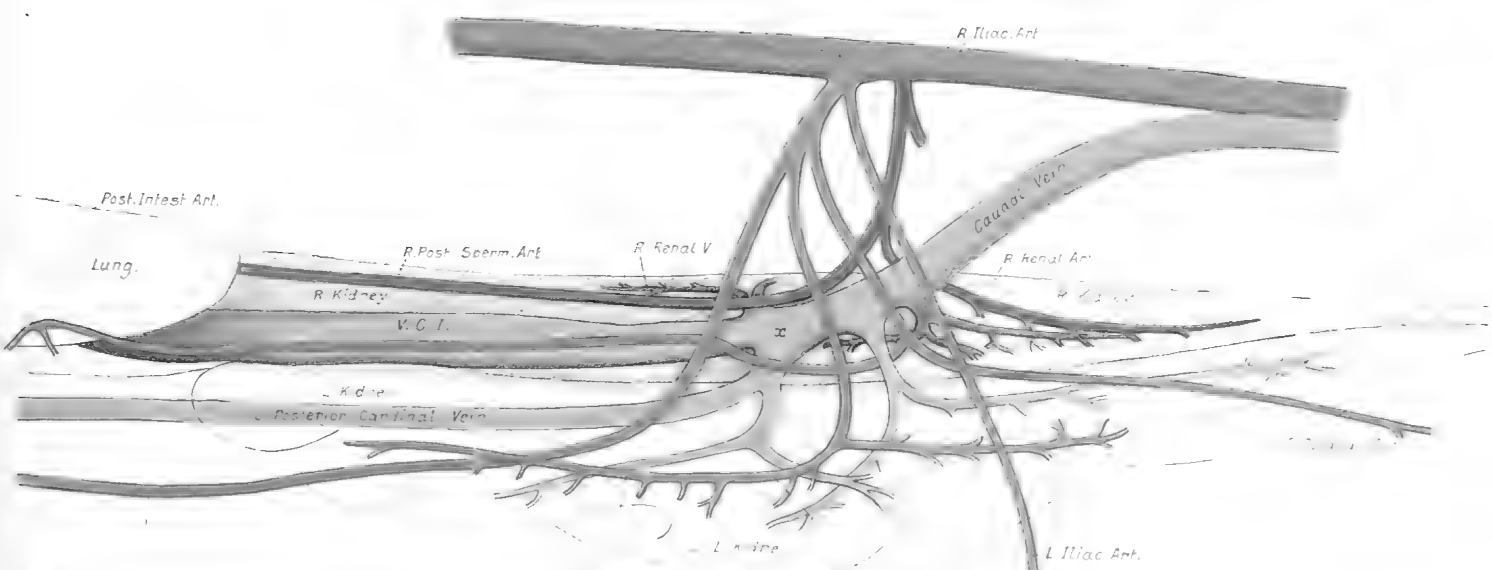


Fig. 10.

W. B. Spencer del.

R. Wendel lith. C. Troedel & Co print

Fig 14

Fig 15

Fig 16

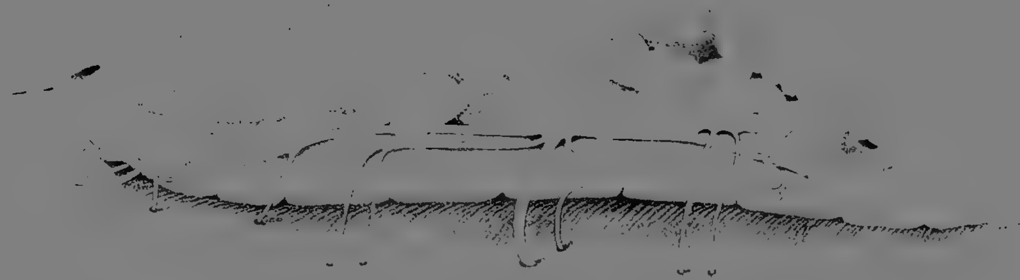


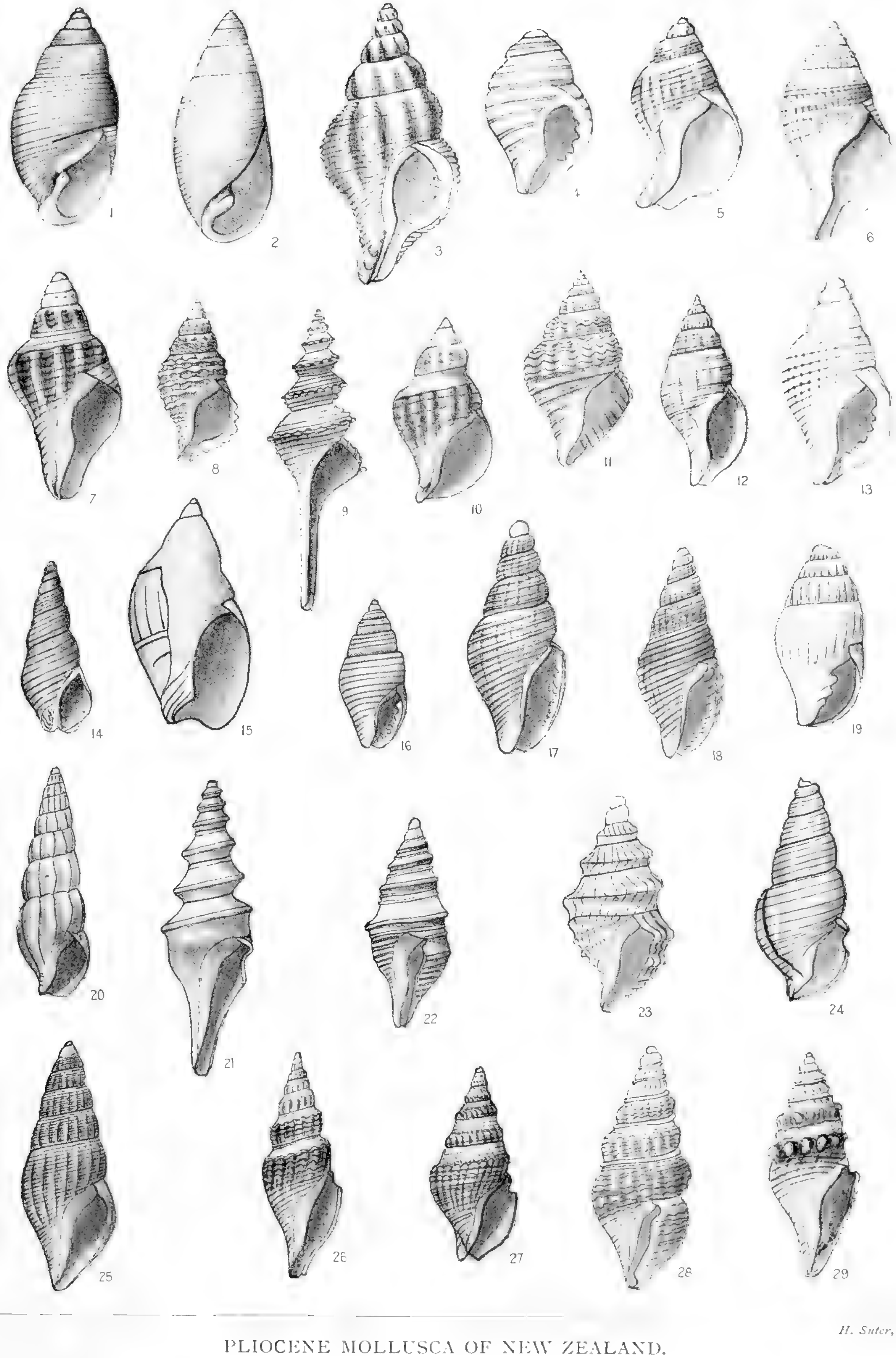
Fig. 19

Fig. 17

Fig. 18

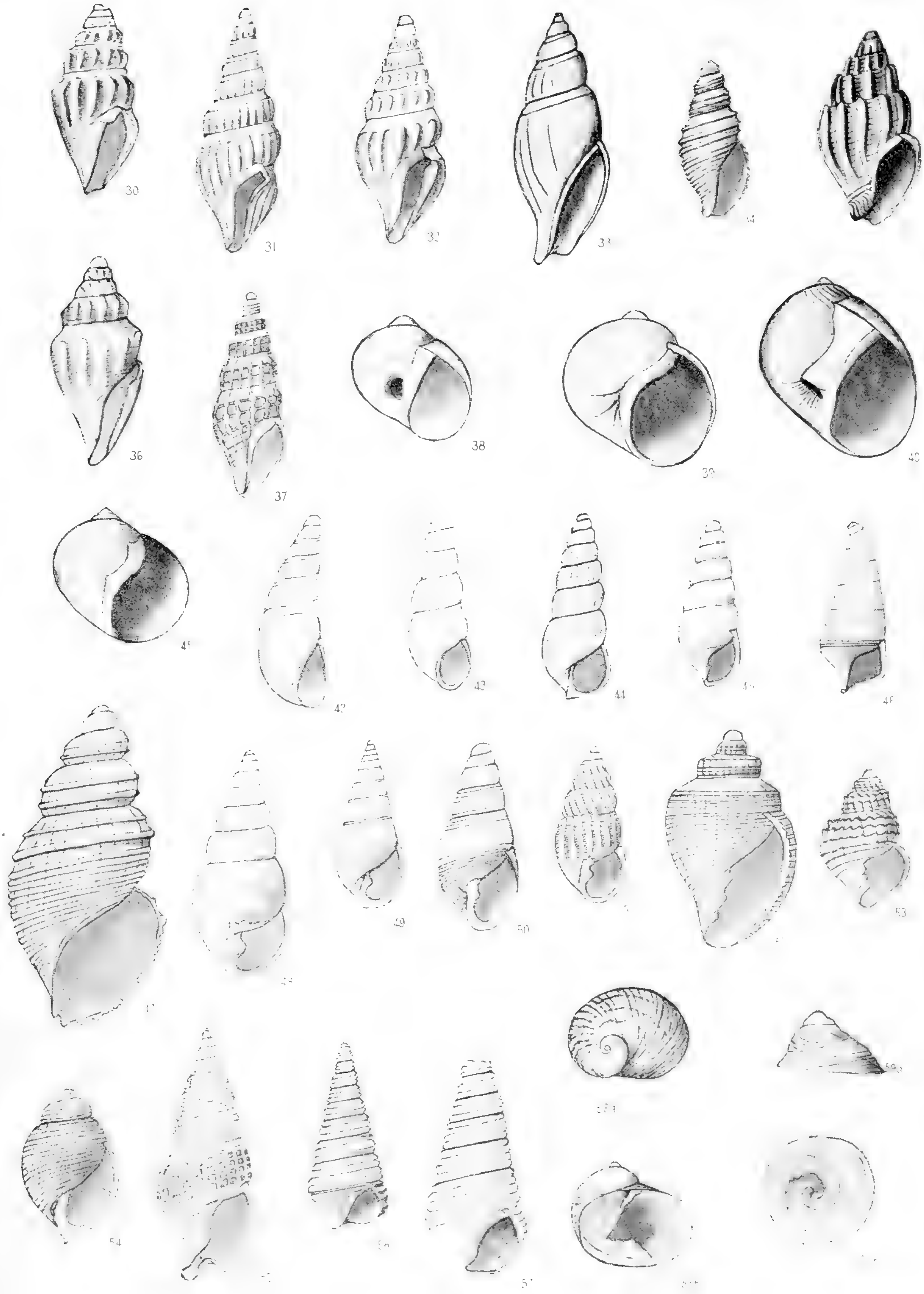
Fig. 20

Fig. 21



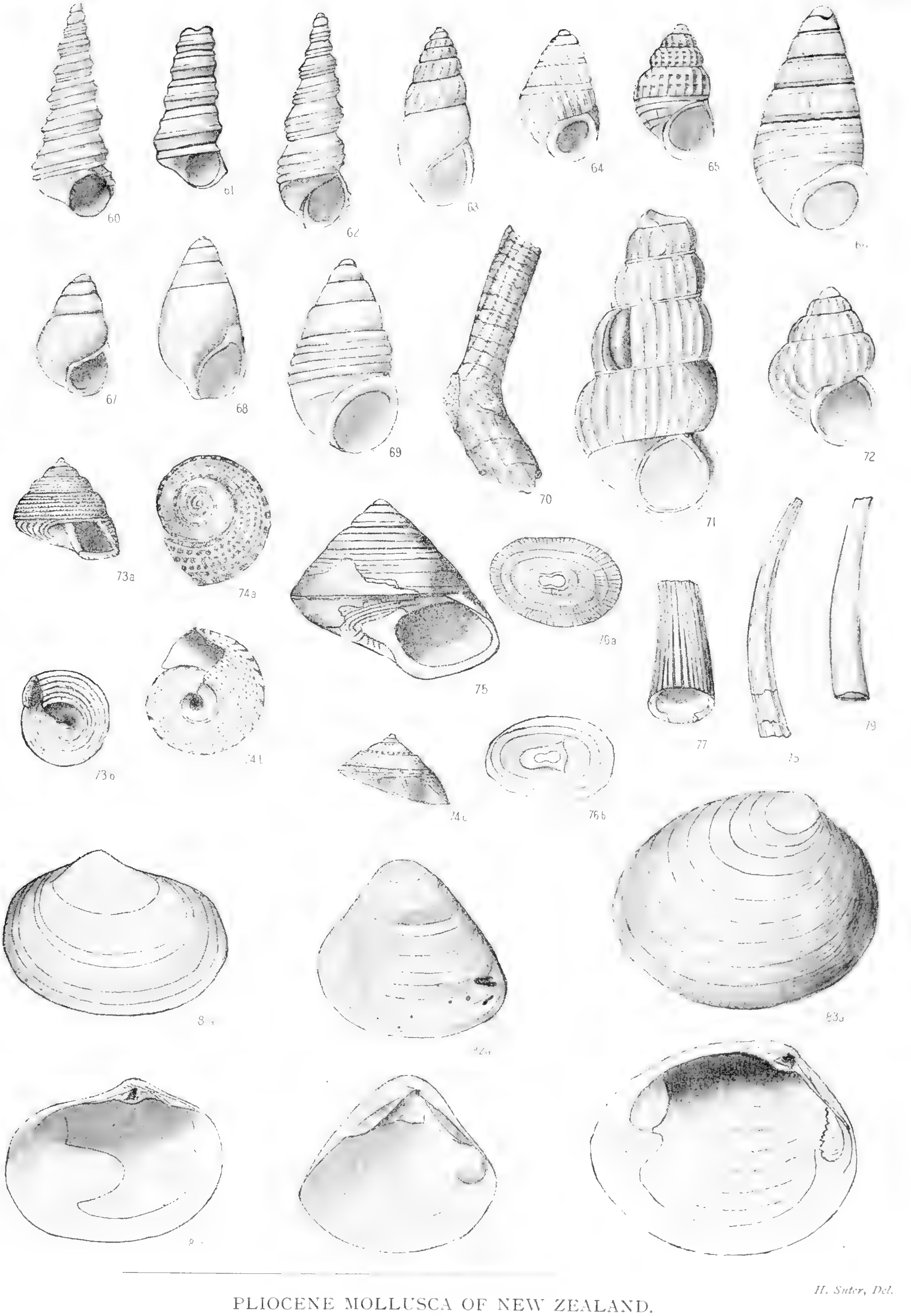
H. Suter, Del.

PLIOCENE MOLLUSCA OF NEW ZEALAND.



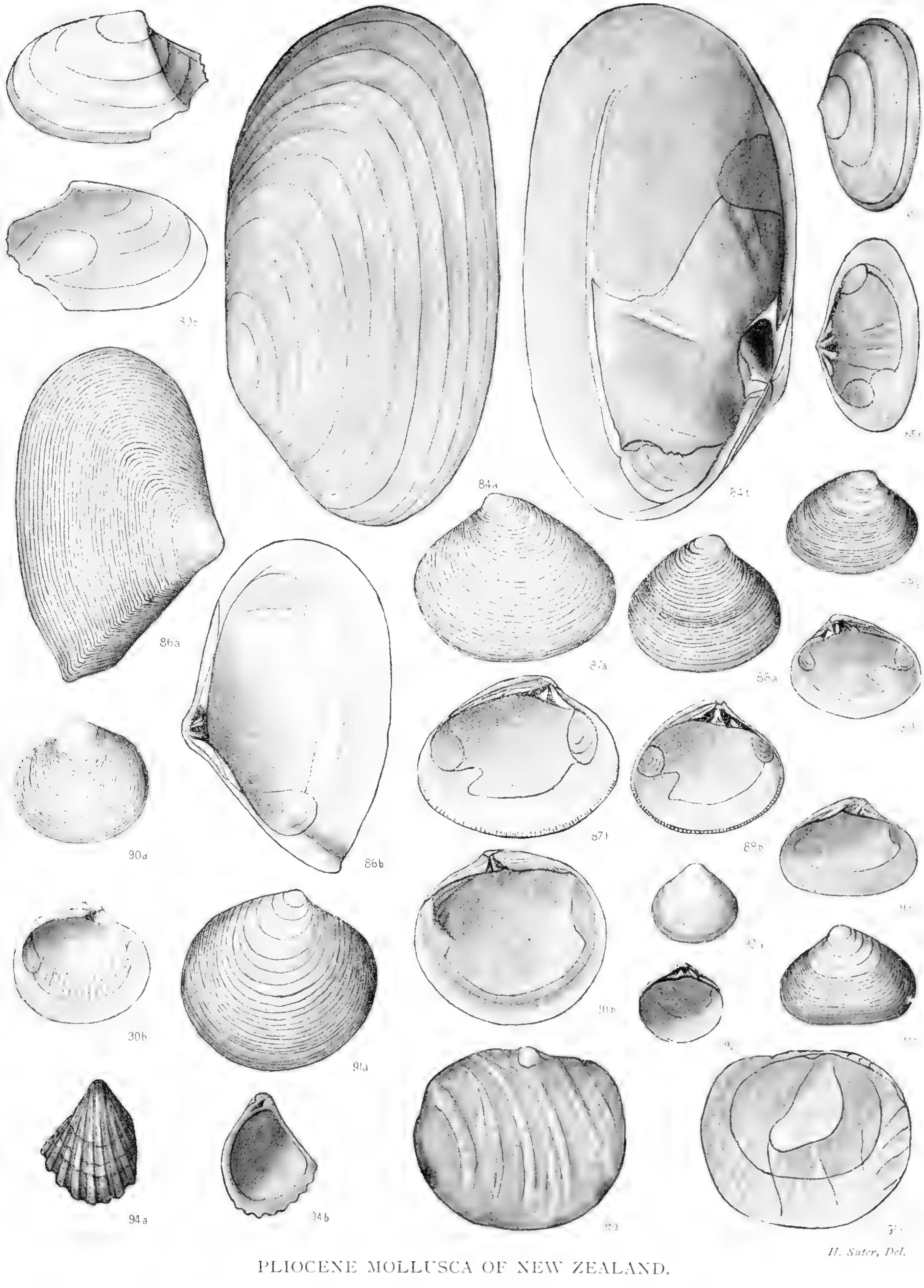
H. Suter. Del.

PLIOCENE MOLLUSCA OF NEW ZEALAND.



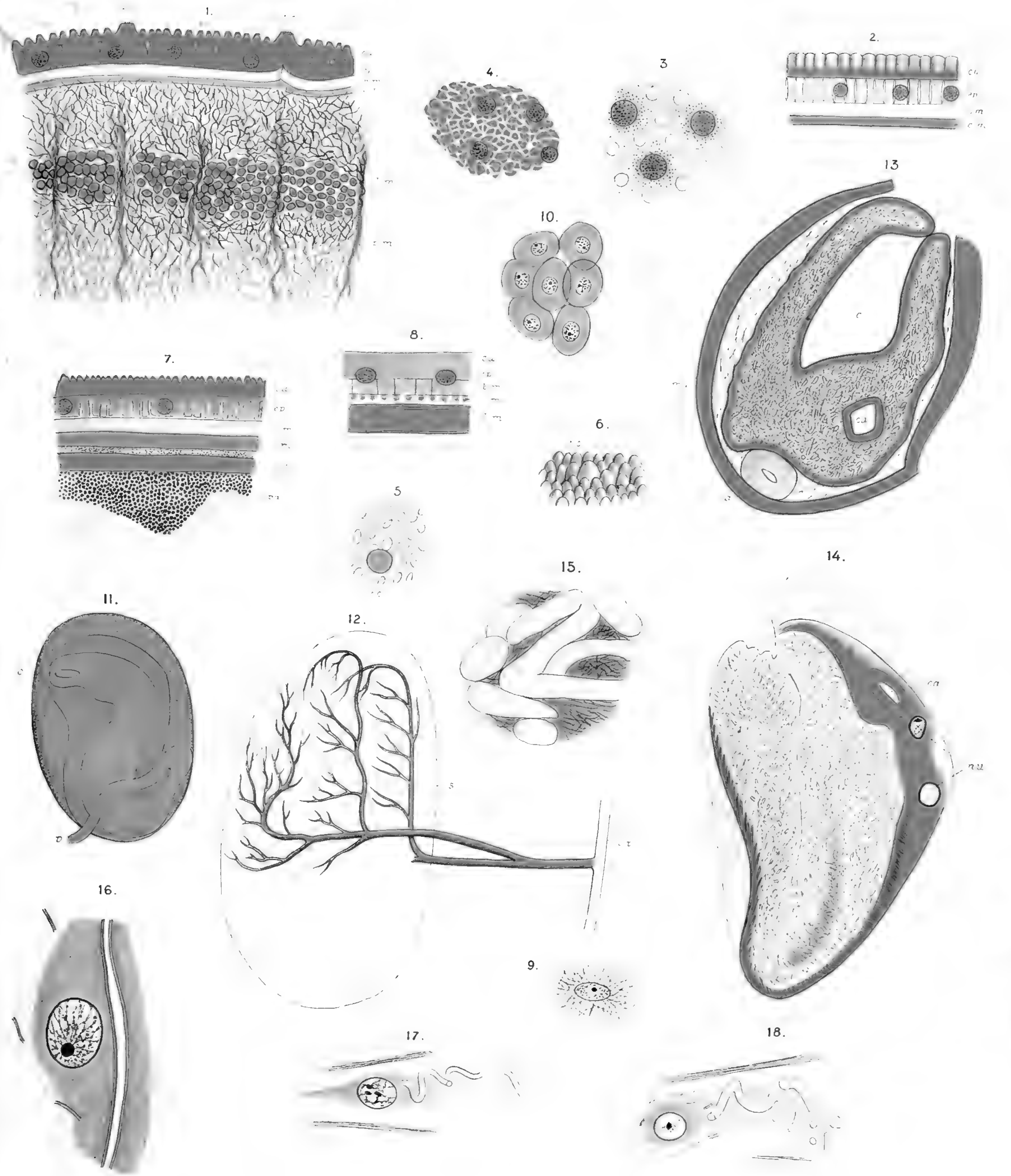
H. Suter, Del.

PLIOCENE MOLLUSCA OF NEW ZEALAND.



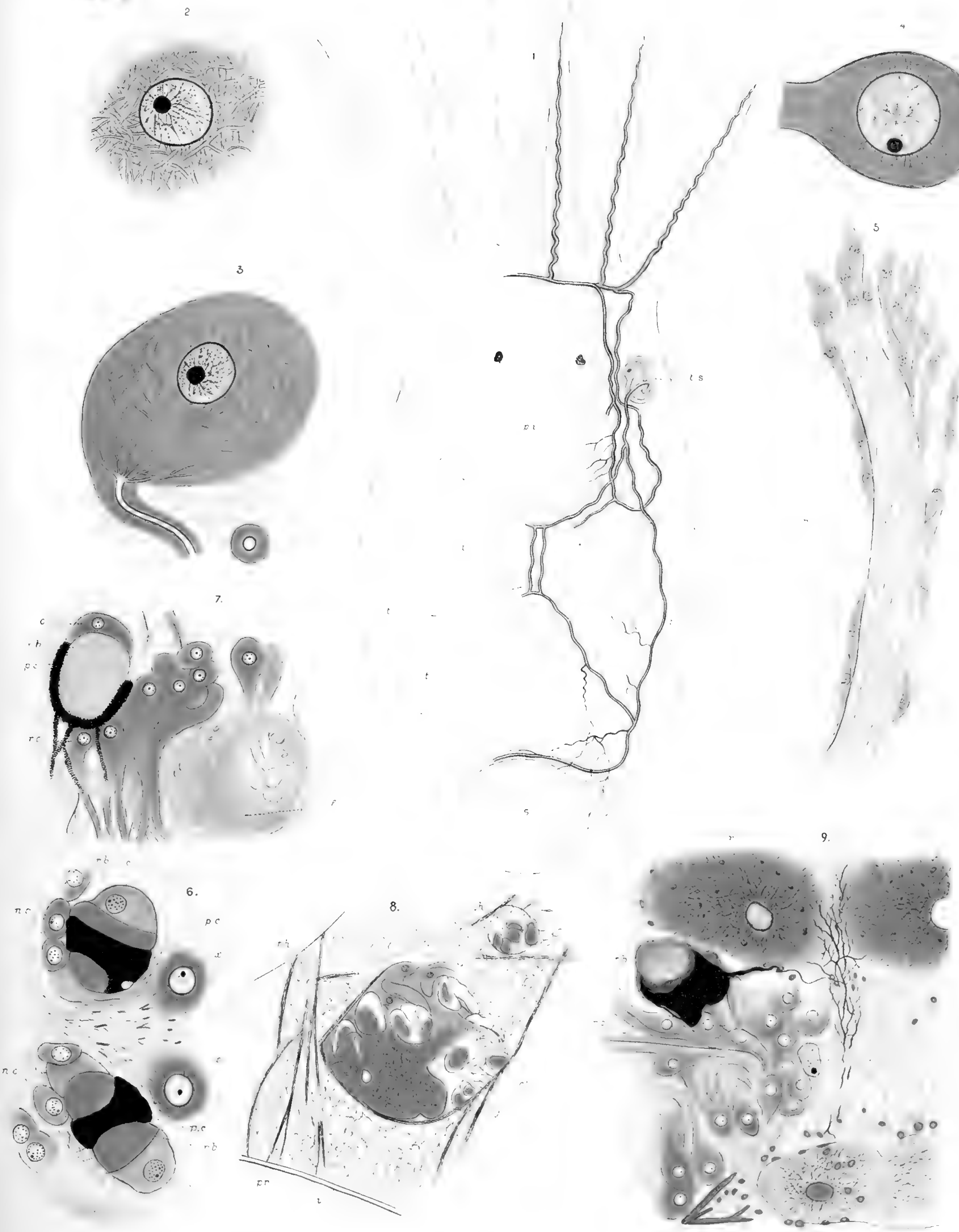
H. Suter, Del.

PLIOCENE MOLLUSCA OF NEW ZEALAND.



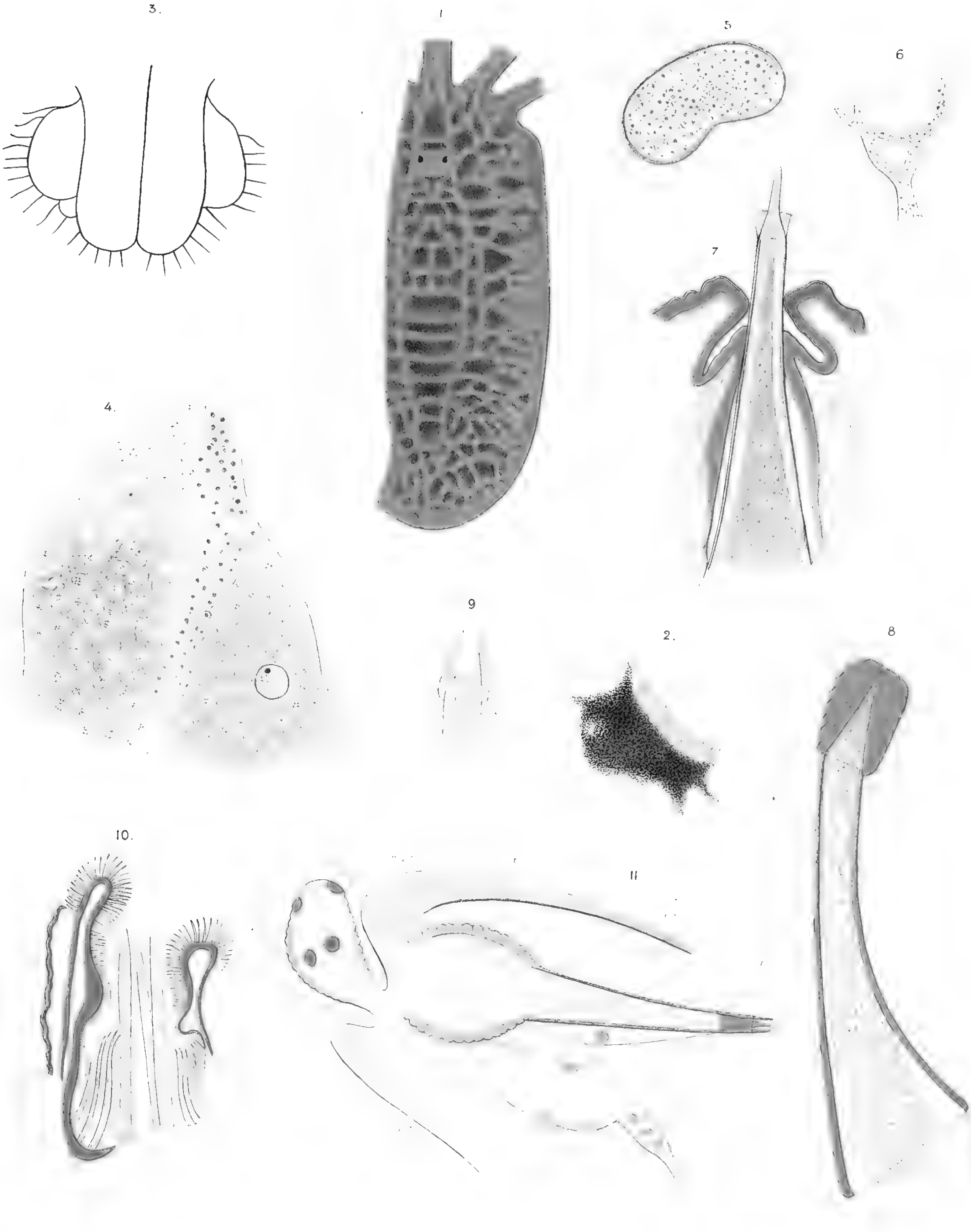
W.A.H. del.

R Wendel lith. C Troedel & Co print Melb

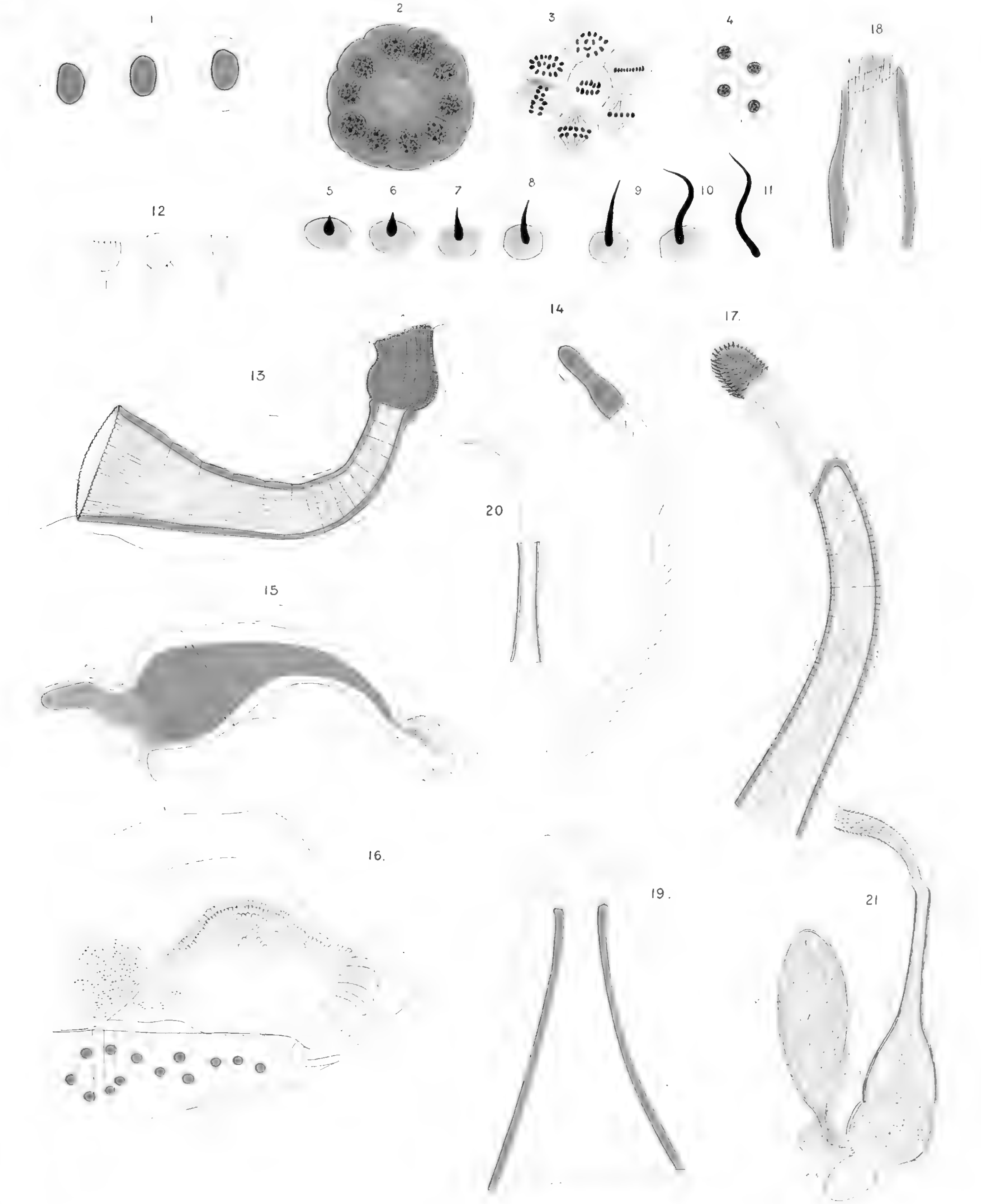


W.A.H. del

R. Wendel Lith. C. Troedel & C° print

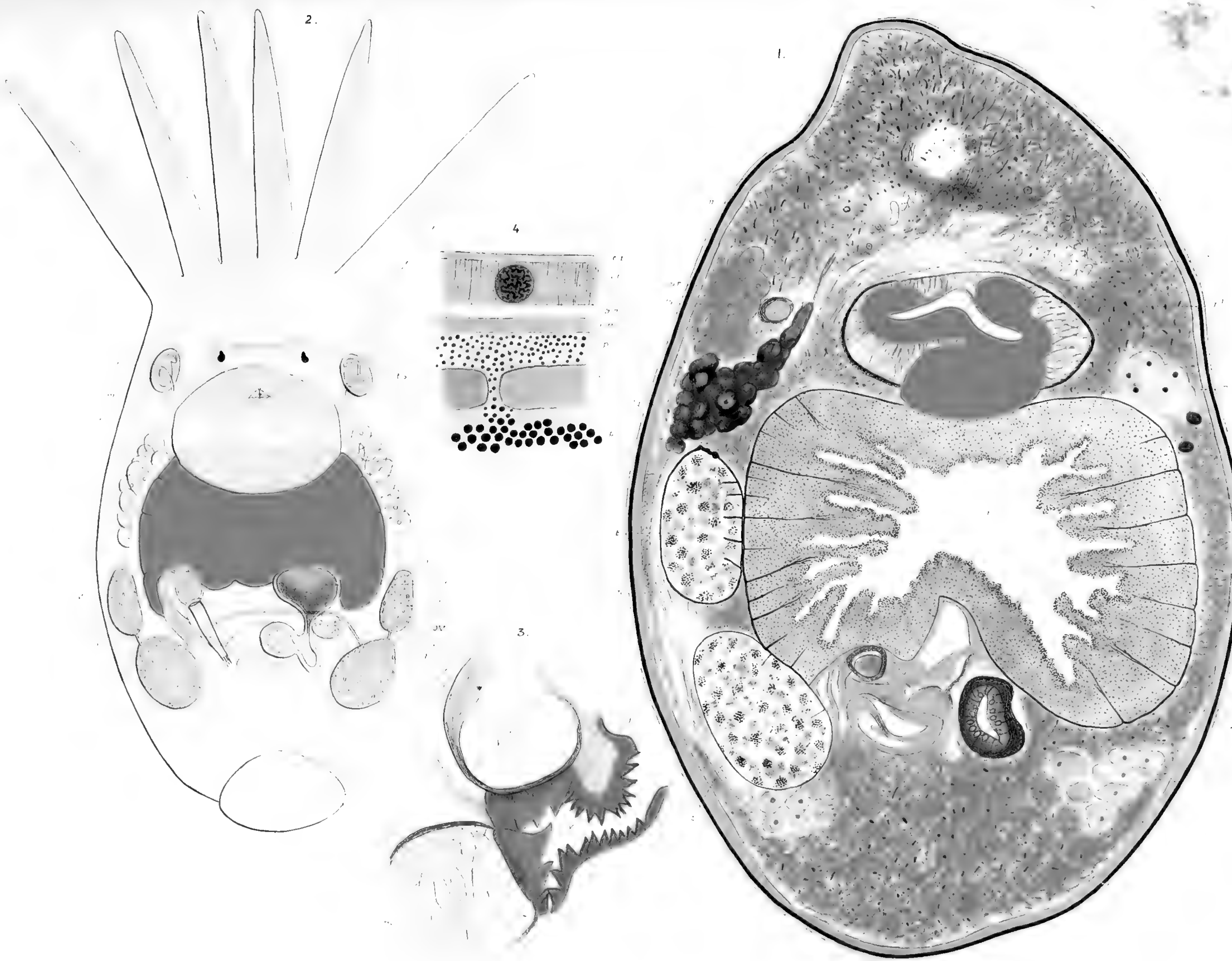


W.A.H. del.



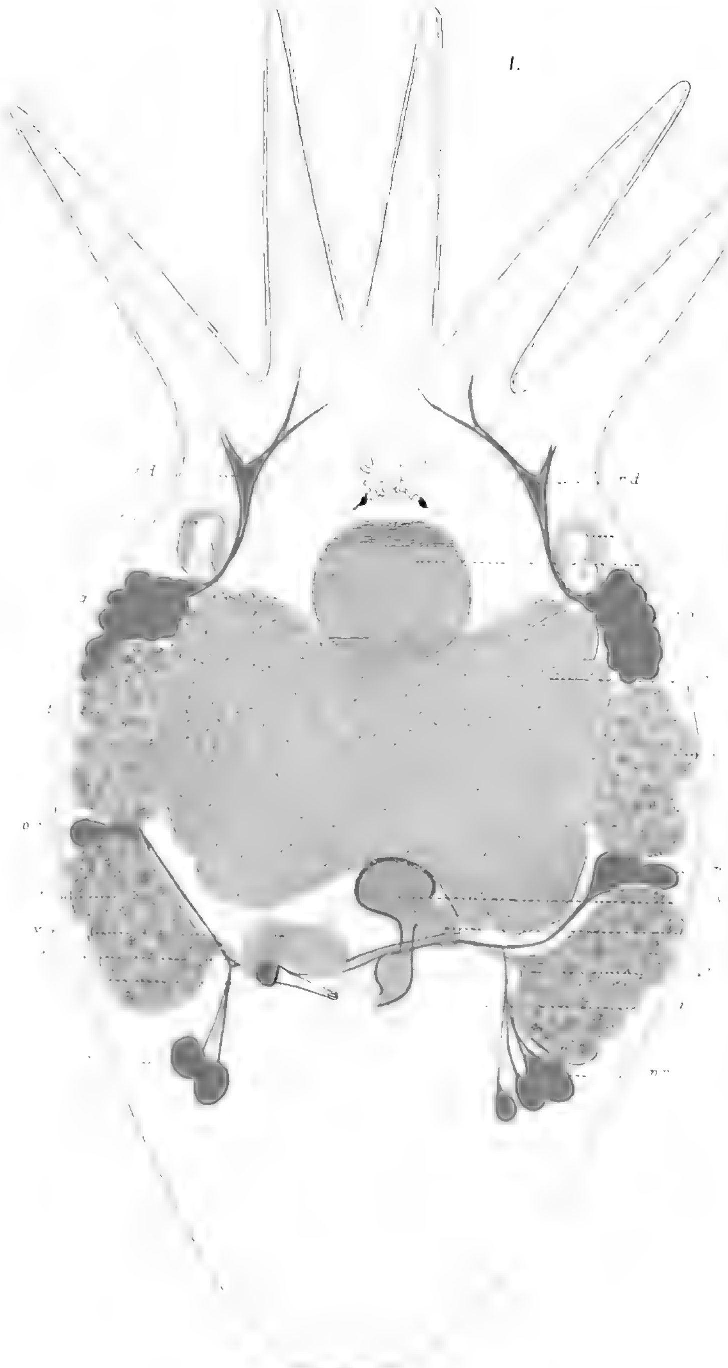
W. A. H. del.

R. Wendel Lith. C. Troedel & Co. imprint Melb.



C. Troedel & Co print Melb

1.



3.

2.

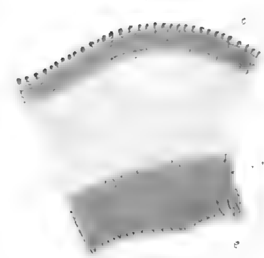
W A H del

T. Wendel lith. Cl[illegible] & Co. print Melb.

1

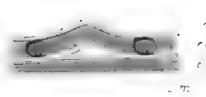
2

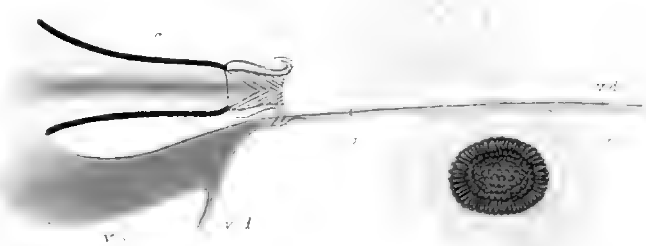
4



5.

3.





W. A. H. del.

R. Wendel lith. C. Troedel & C° print. Melb.

Fig 1.

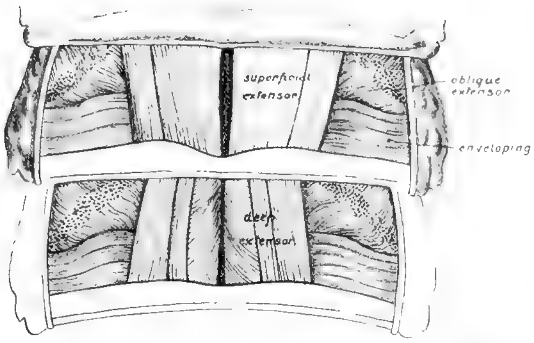


Fig. 2

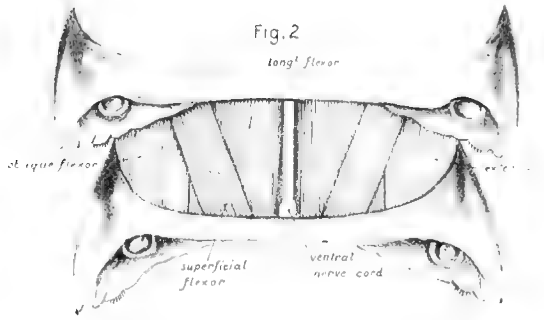


Fig. 3.

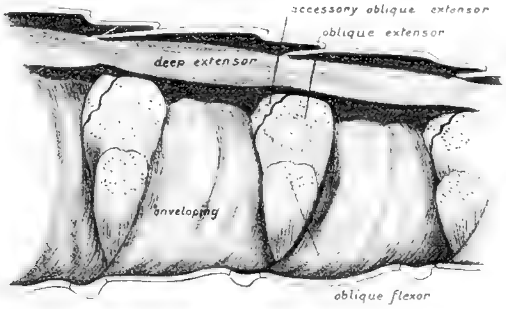


Fig 4.

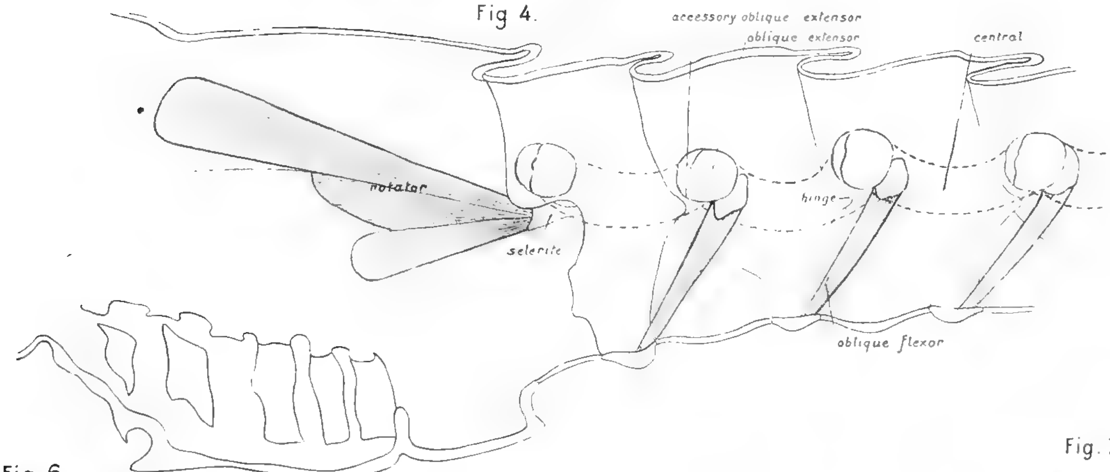


Fig 6.

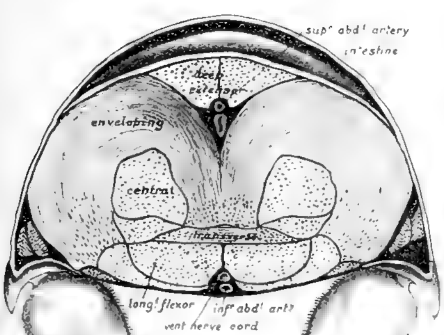


Fig. 5.

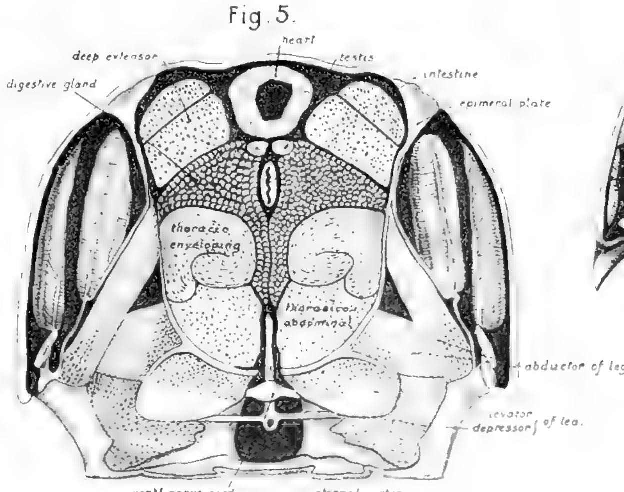
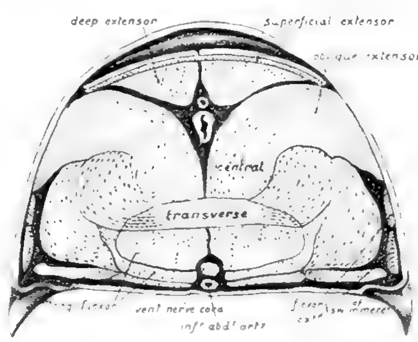


Fig. 7.



J. G. R. ad nat. delt.

MYOLOGY OF PALINURUS.

R. Wendel lith.

Fig 8.

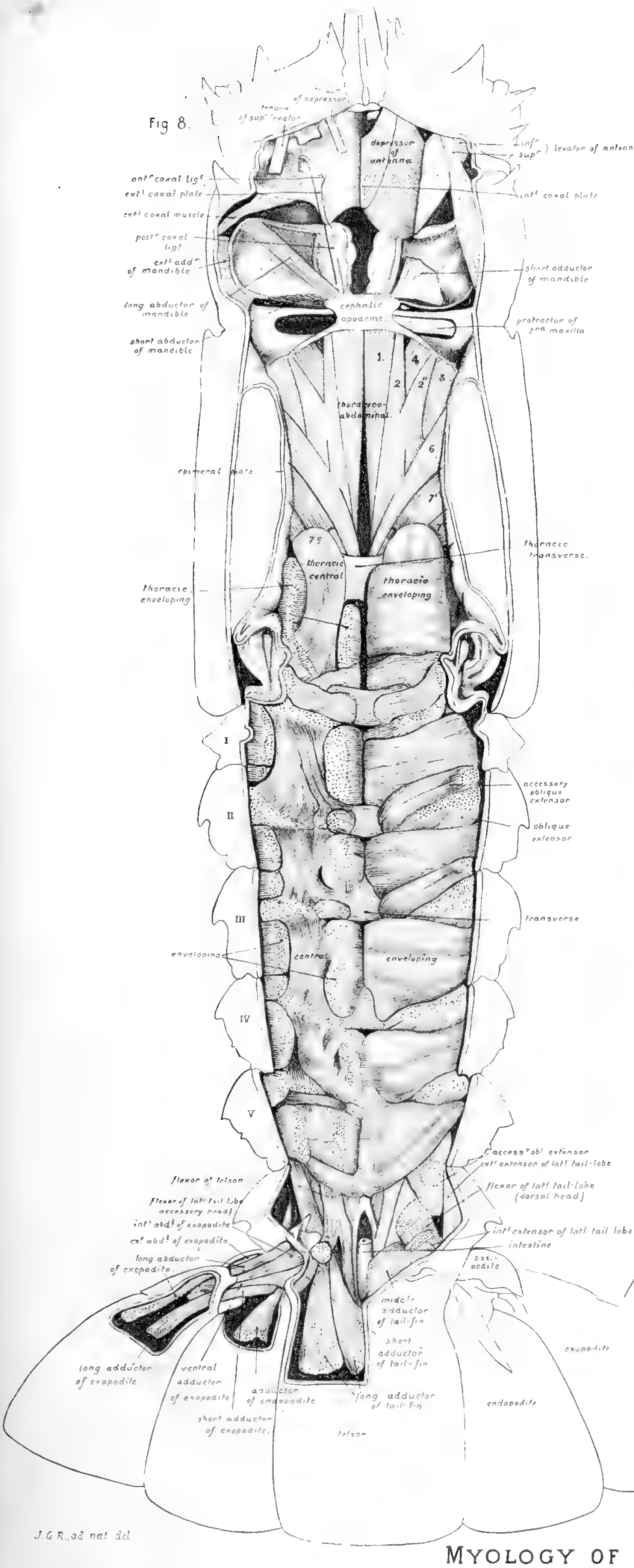
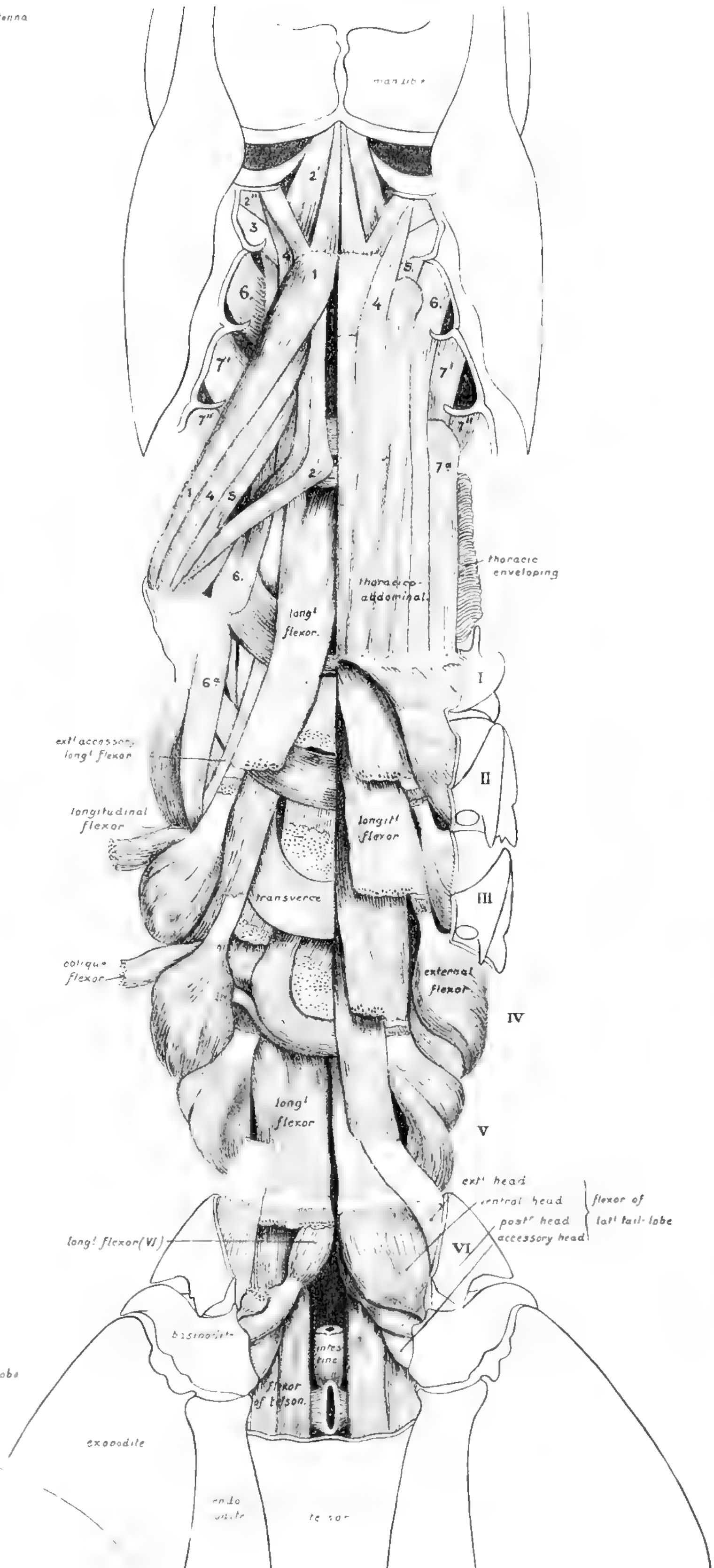


Fig 9



J.G.R. ad nat. del.

R. Wendel lith. C. Troedel & Co print. Melb.

MYOLOGY OF PALINURUS.

Fig. 10.

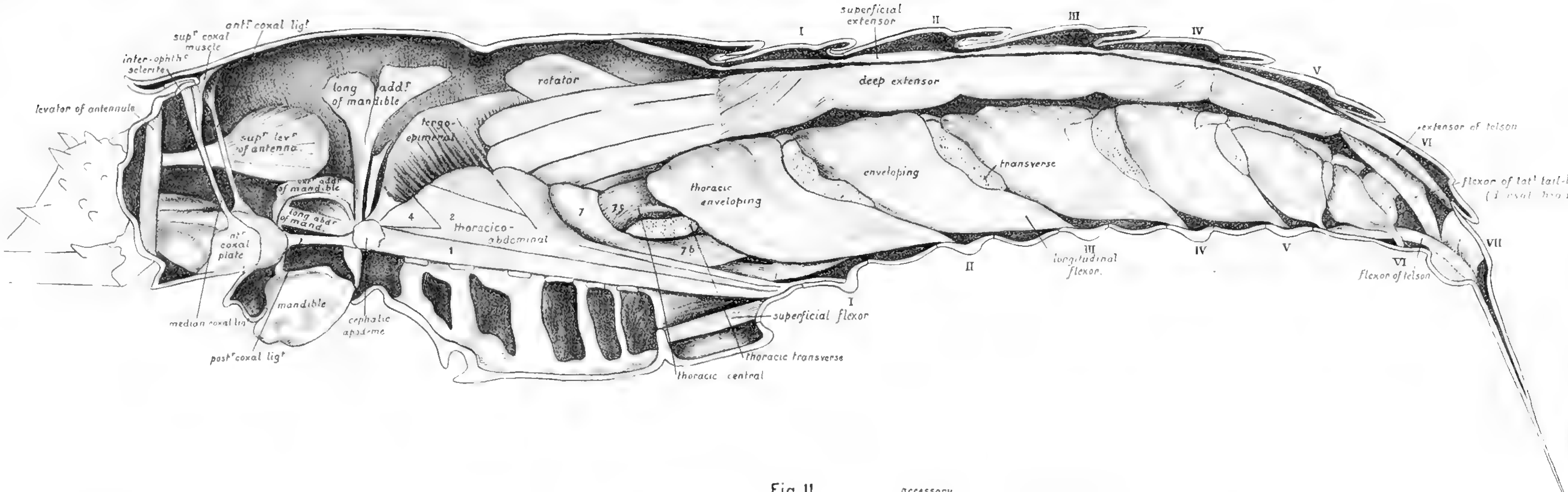
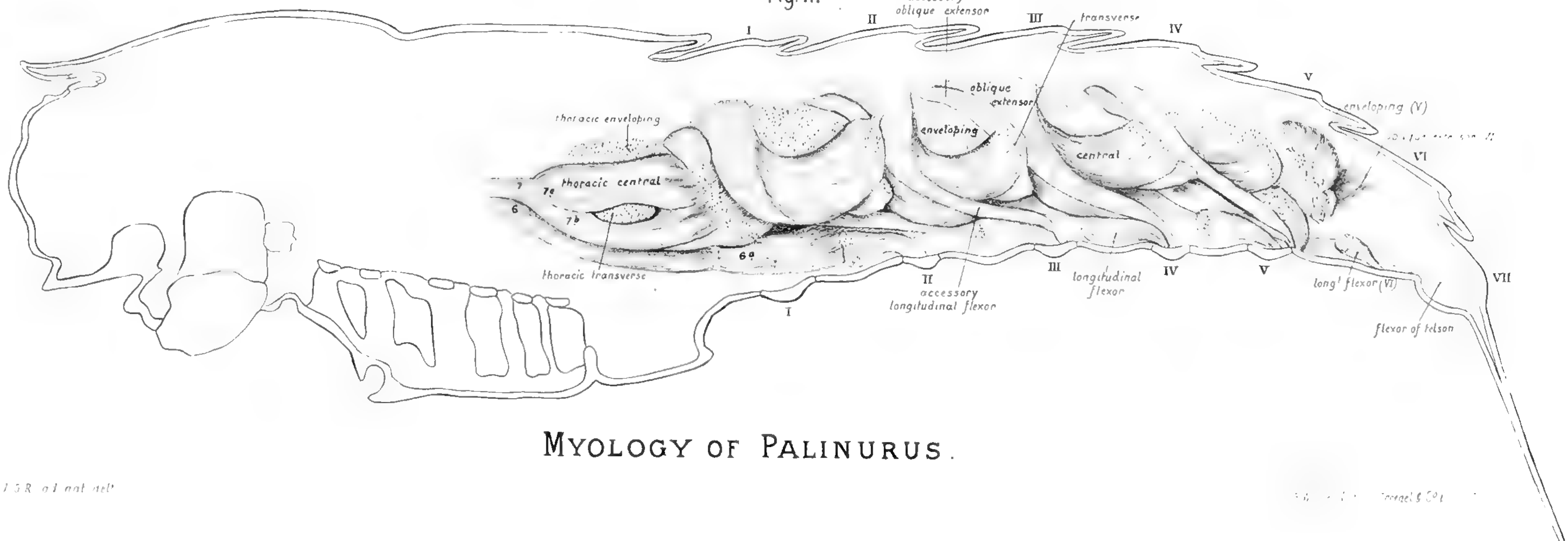
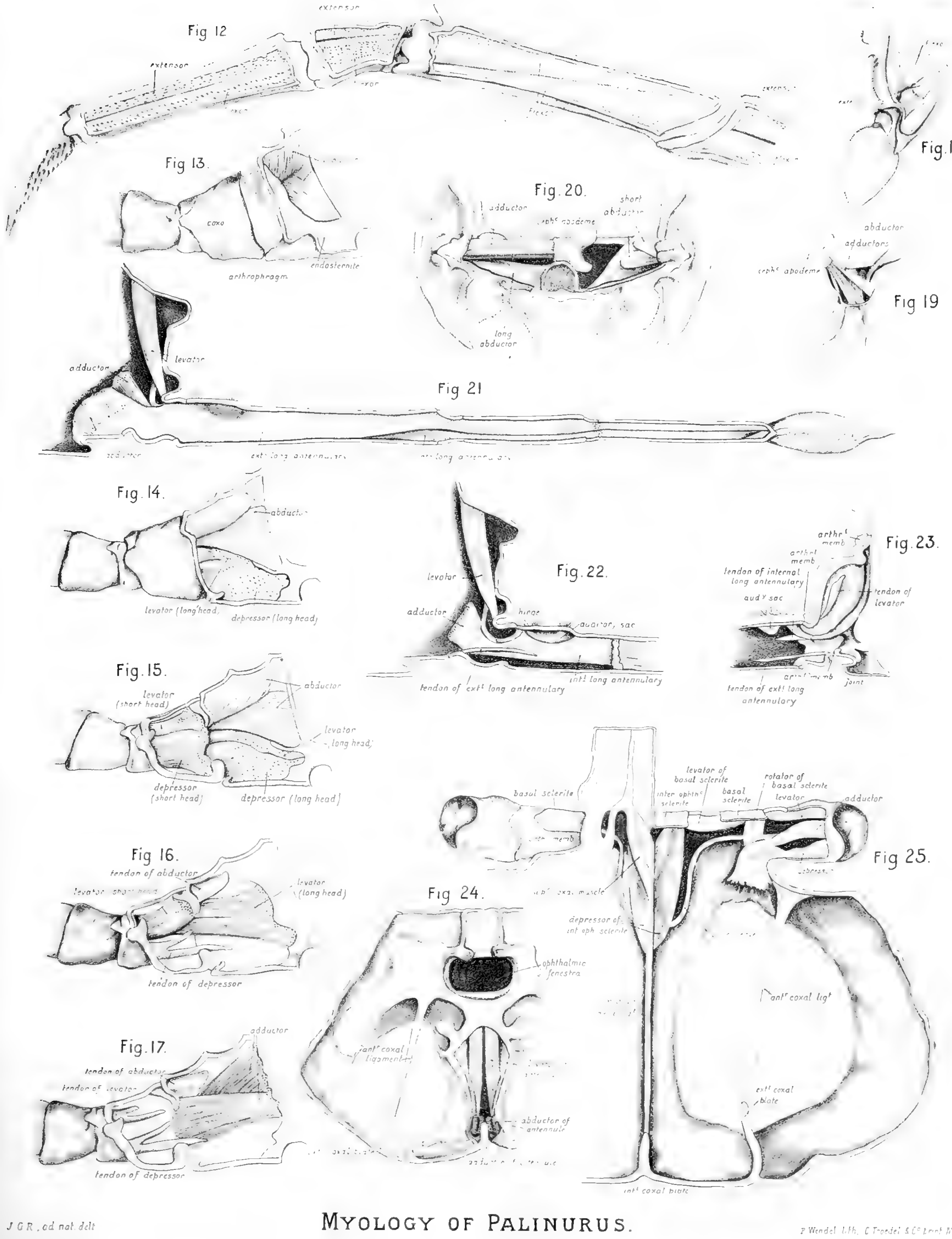


Fig. 11.



Myology of Palinurus.

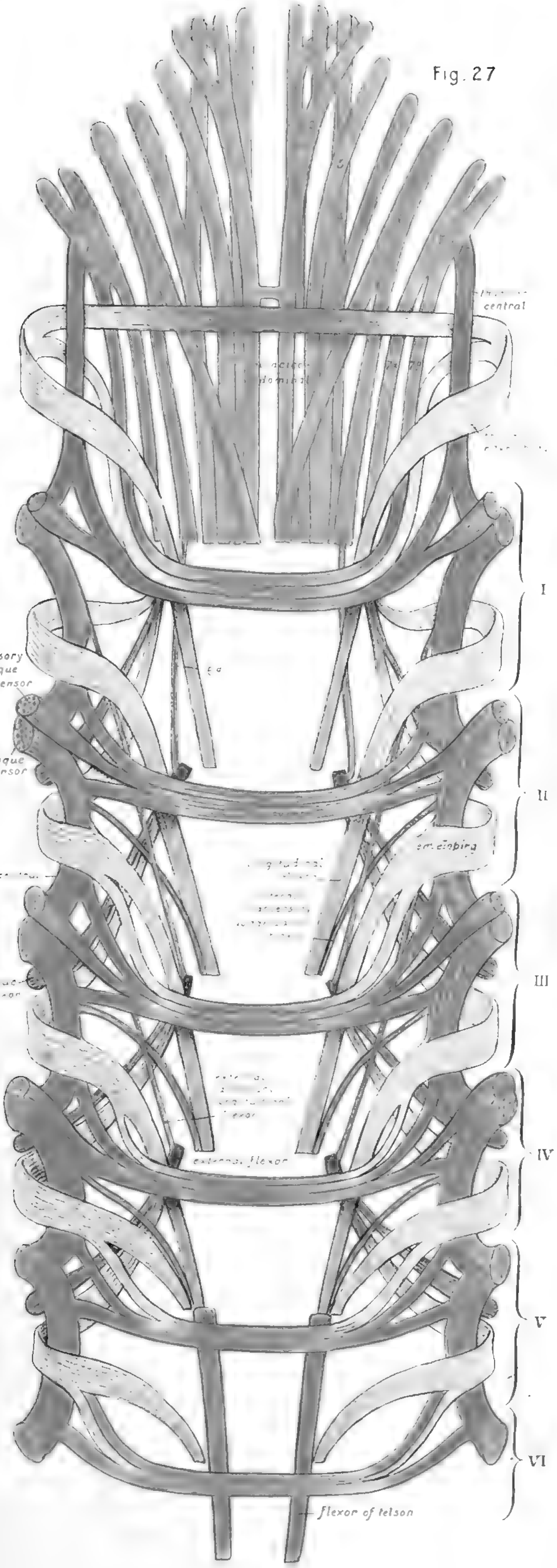
J. G. R. ad nat. delt

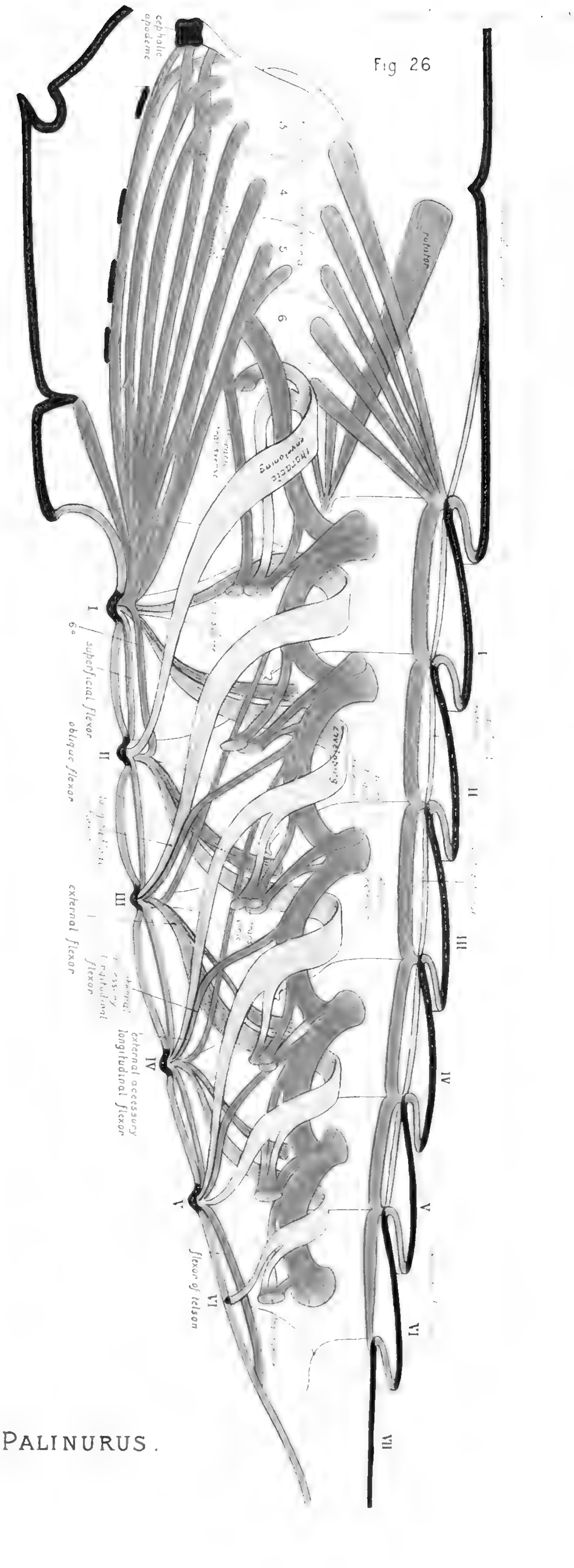


J. G. R. ad nat. delt.

MYOLOGY OF PALINURUS.

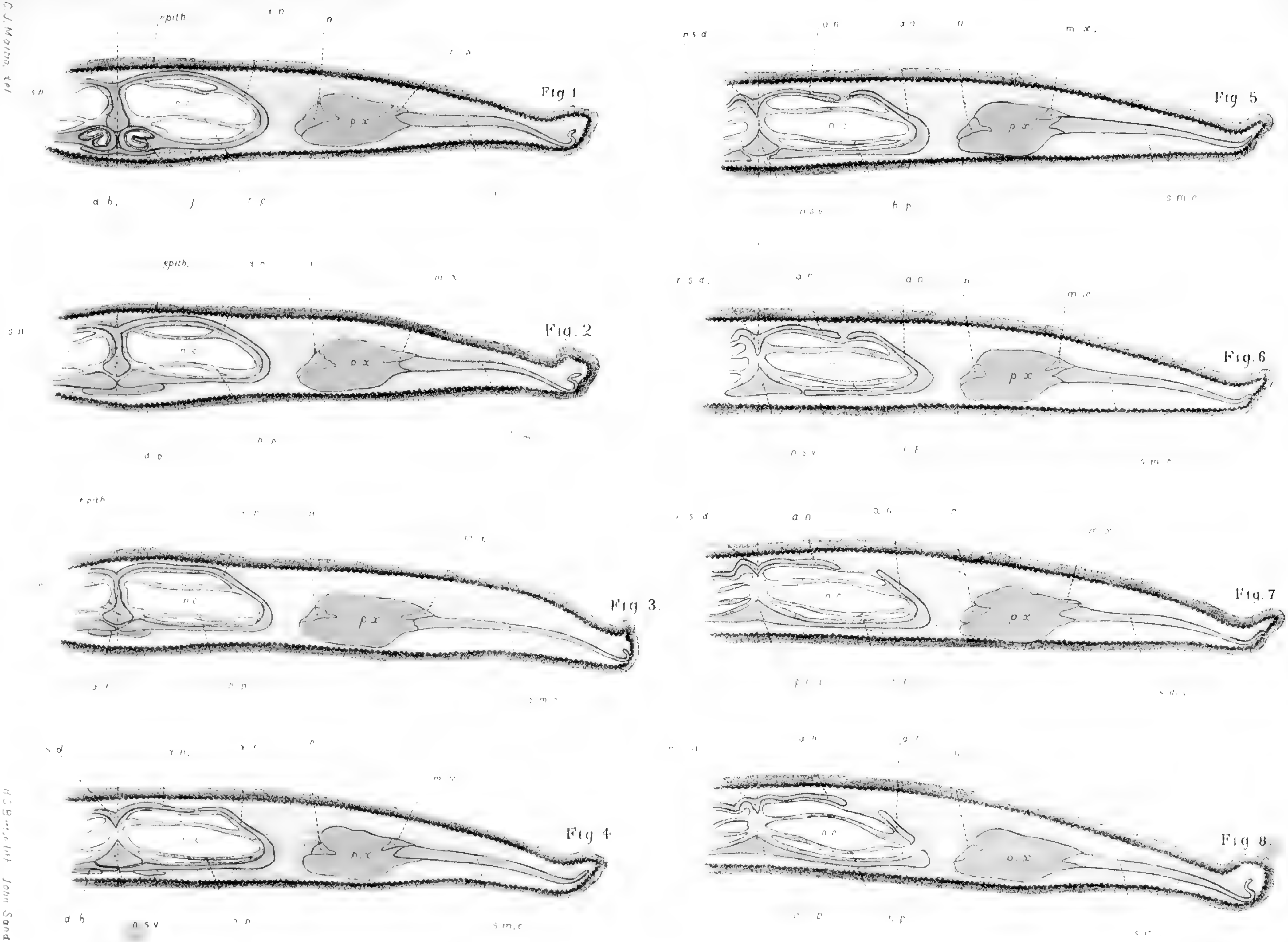
P. Wendel lith. C. Troedel & Co. Lmet. Melb.





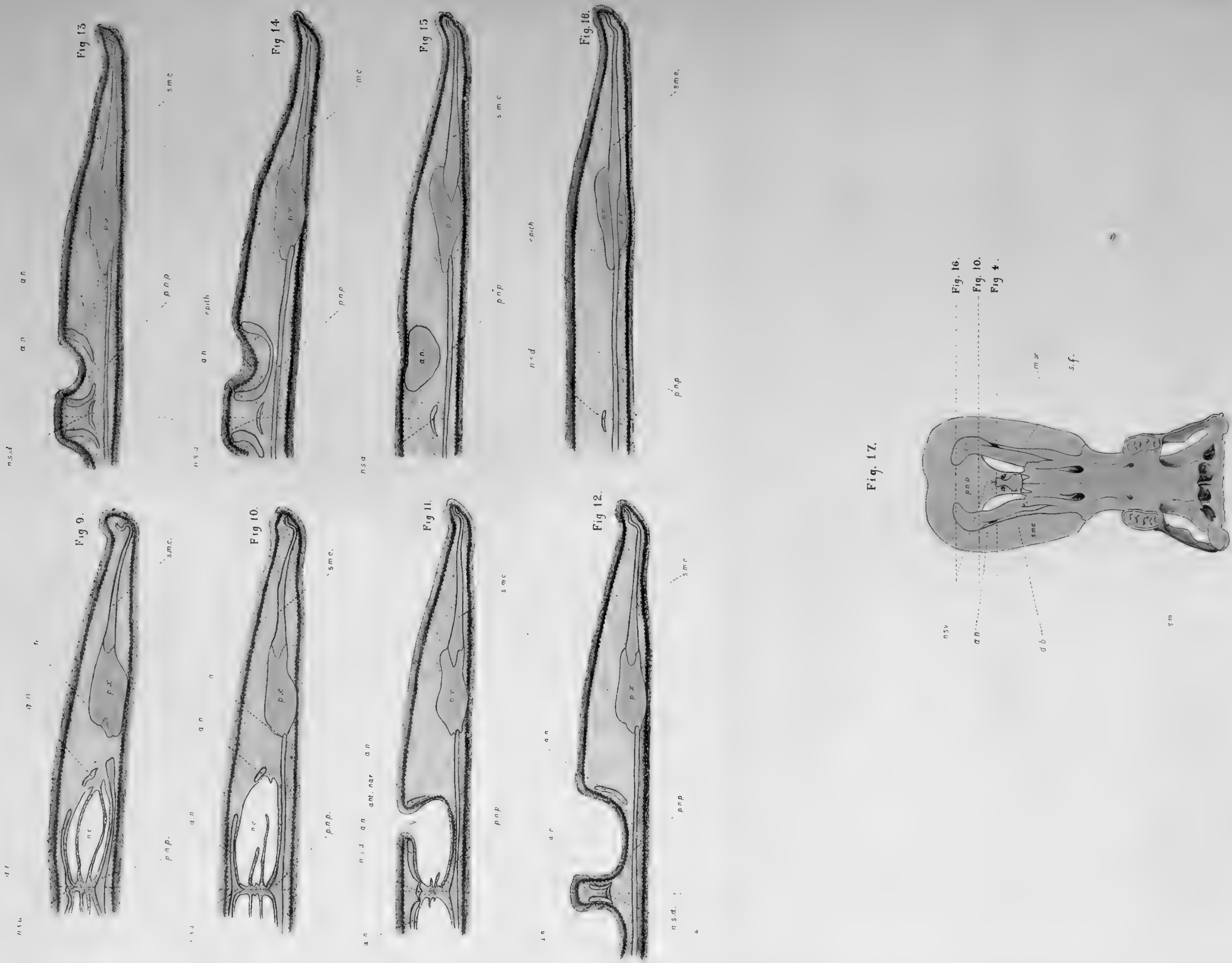
MYOLOGY OF PALINURUS.

R. Wendel lith. C. Troedel & Co. print



C. J. Martin, del.

H. S. Bird, lith. John Sands, print.



C. J. Martin, del.

H. S. Burton, lith. John Sands print

Fig. 1

Fig. 2

Fig. 3

Fig. 4

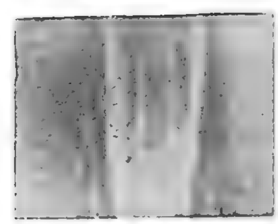


Fig. 5

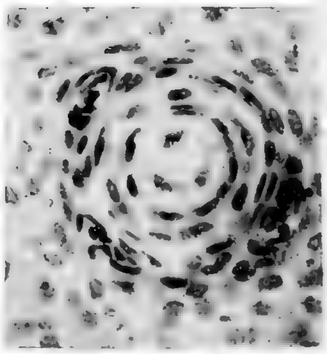


Fig. 6

The Photoline Printing Co., Sydney.

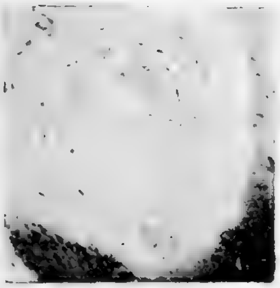


Fig. 7

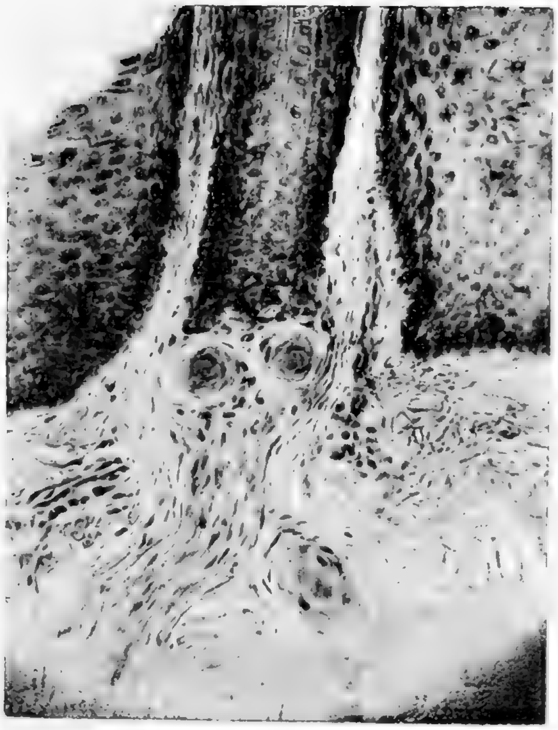


Fig. 8

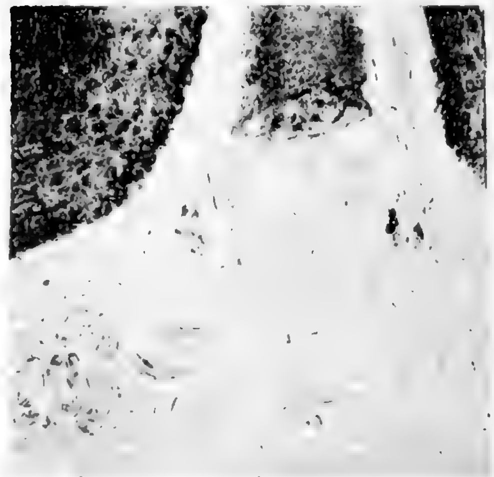


Fig. 9

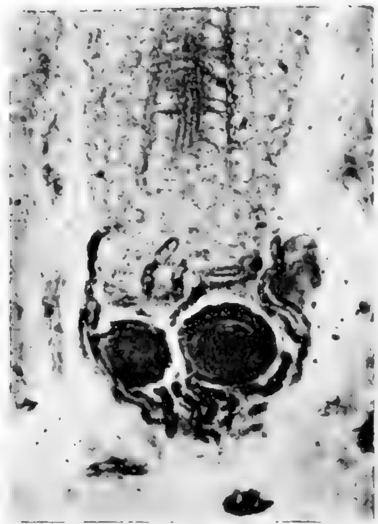


Fig. 11

Fig. 10

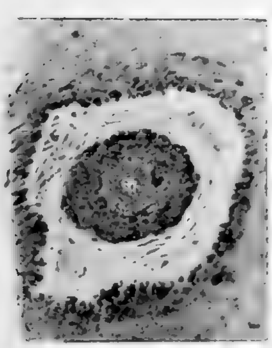


Fig. 13

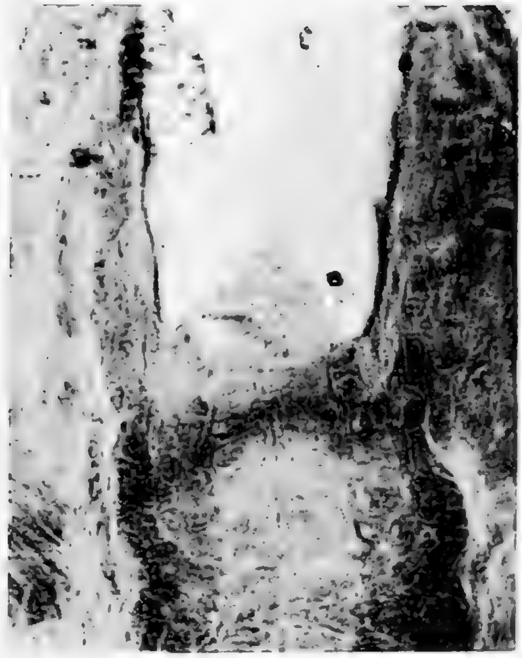
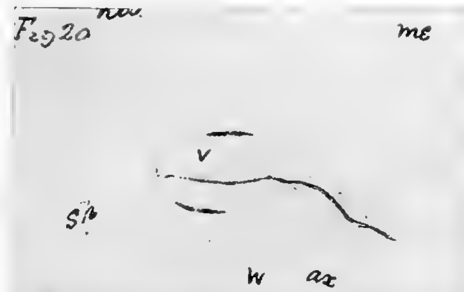
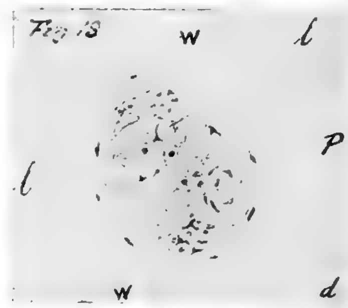
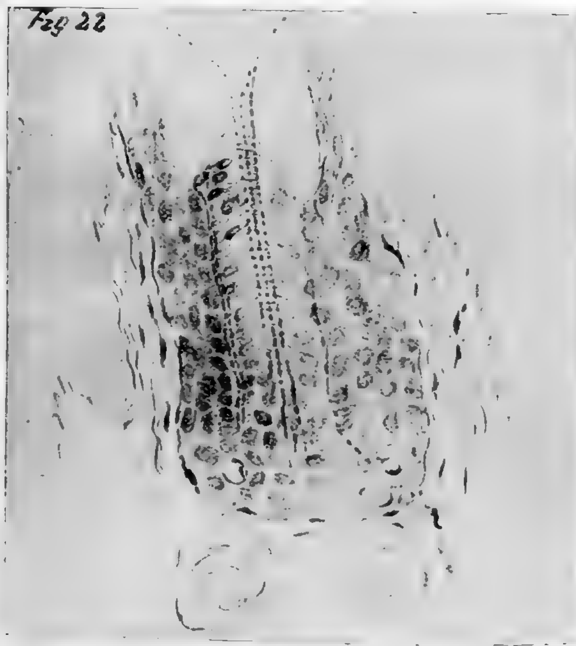


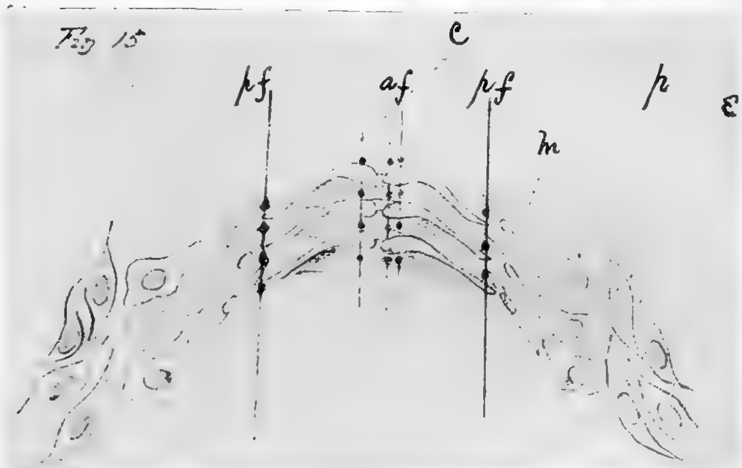
Fig. 12

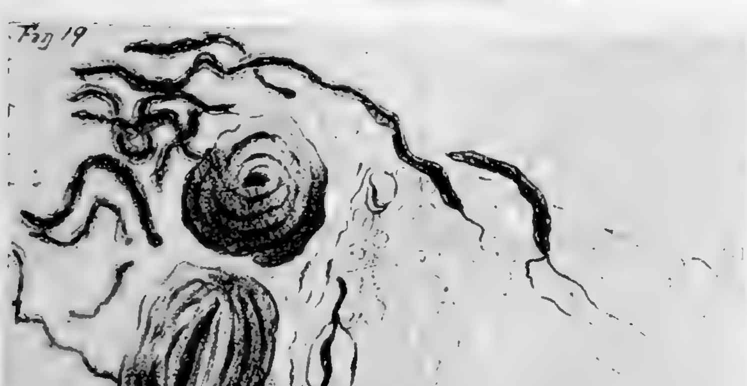
The Photoline Printing Co., Sydney

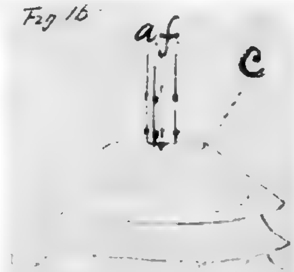


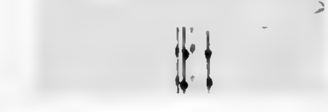






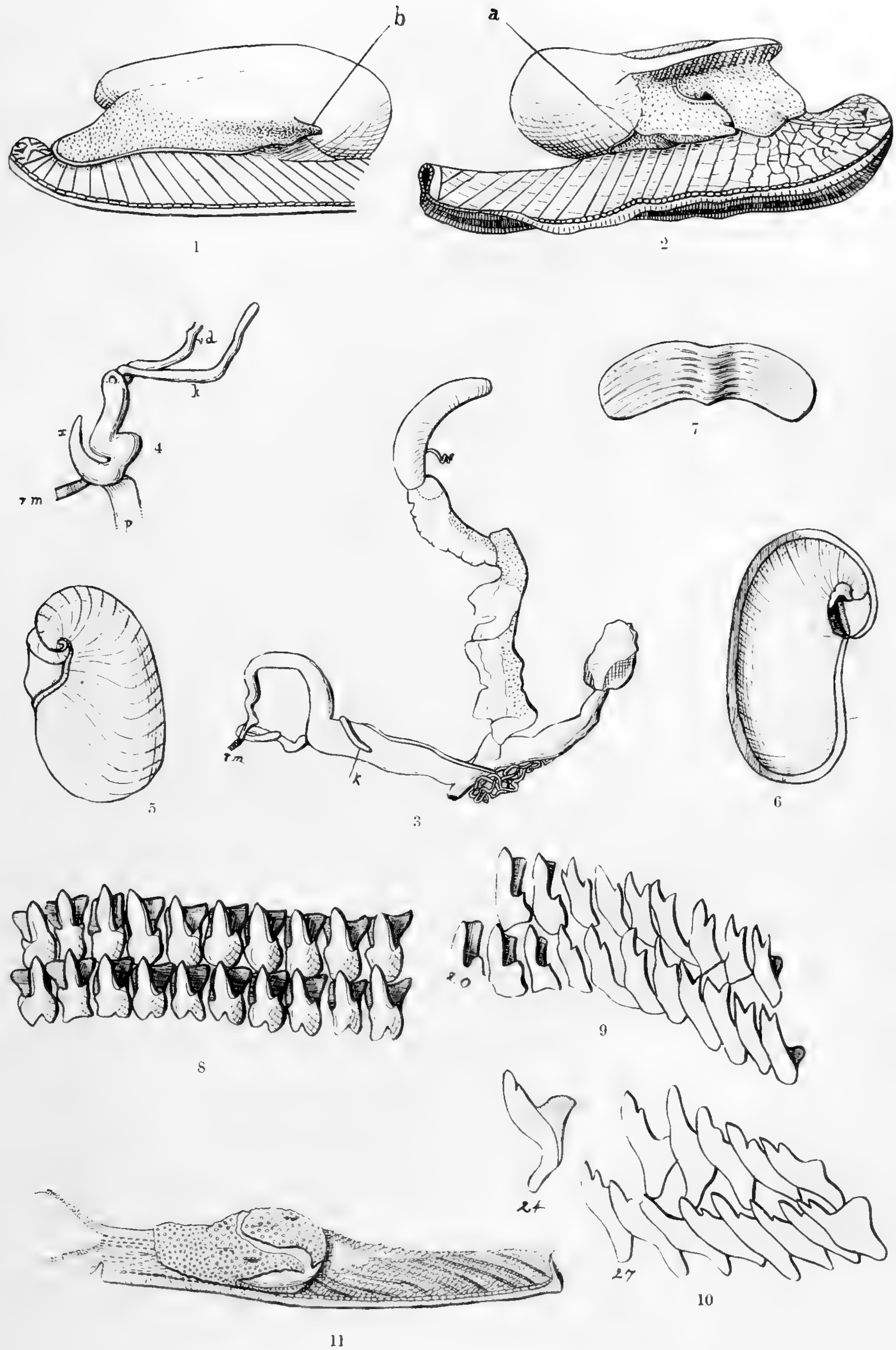






C.J.M., delt.

The Photoline Printing Co., Sydney.



C. Hedley, del. PARMOCOCHLEA FISCHERI, Sm. *The Photoline Printing Co., Sydney*

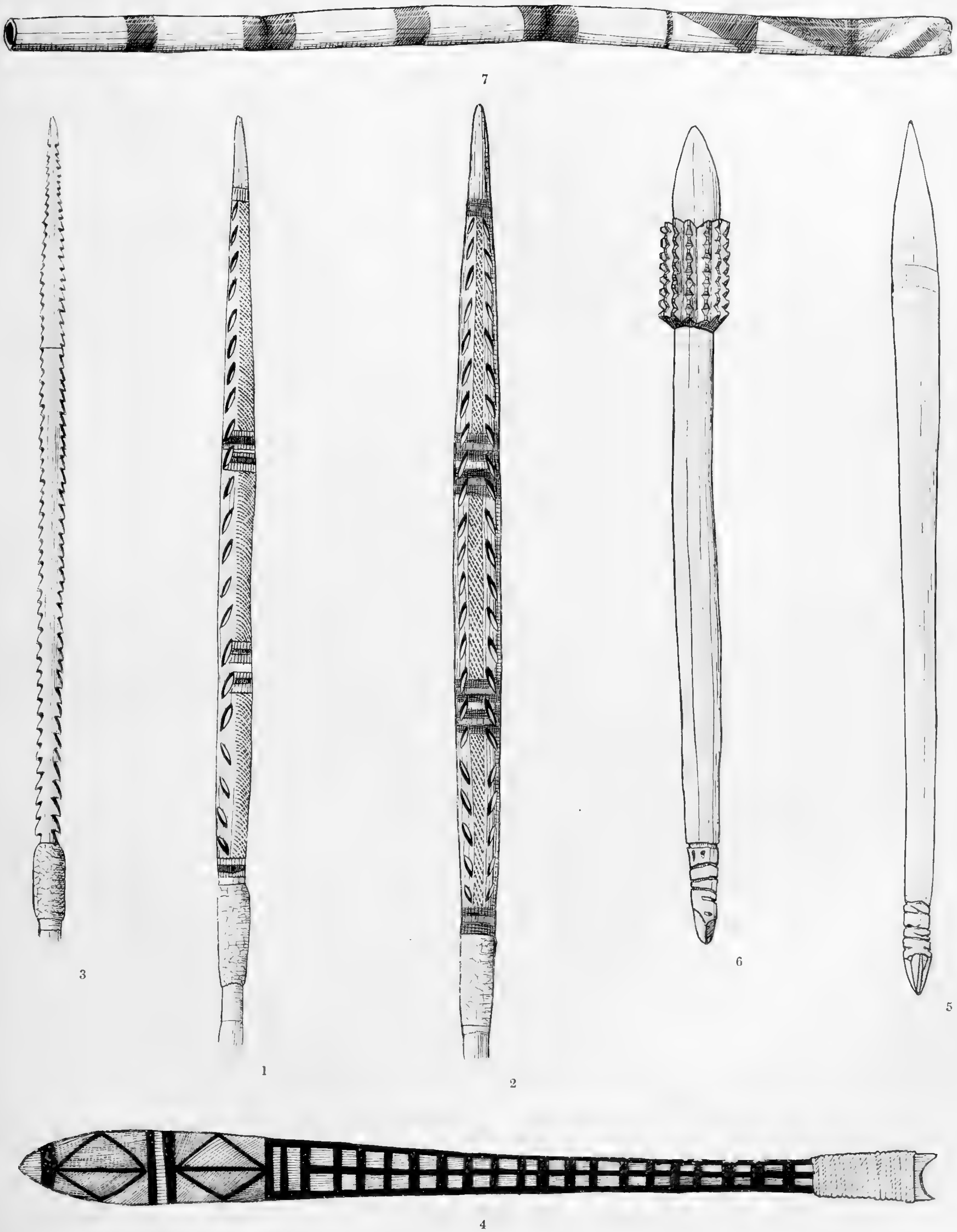
R.T Baker del ad nat.

ACACIA MAIDENII, F.v.M.

E.J. Carver, lith

R. T Baker del. ad nat

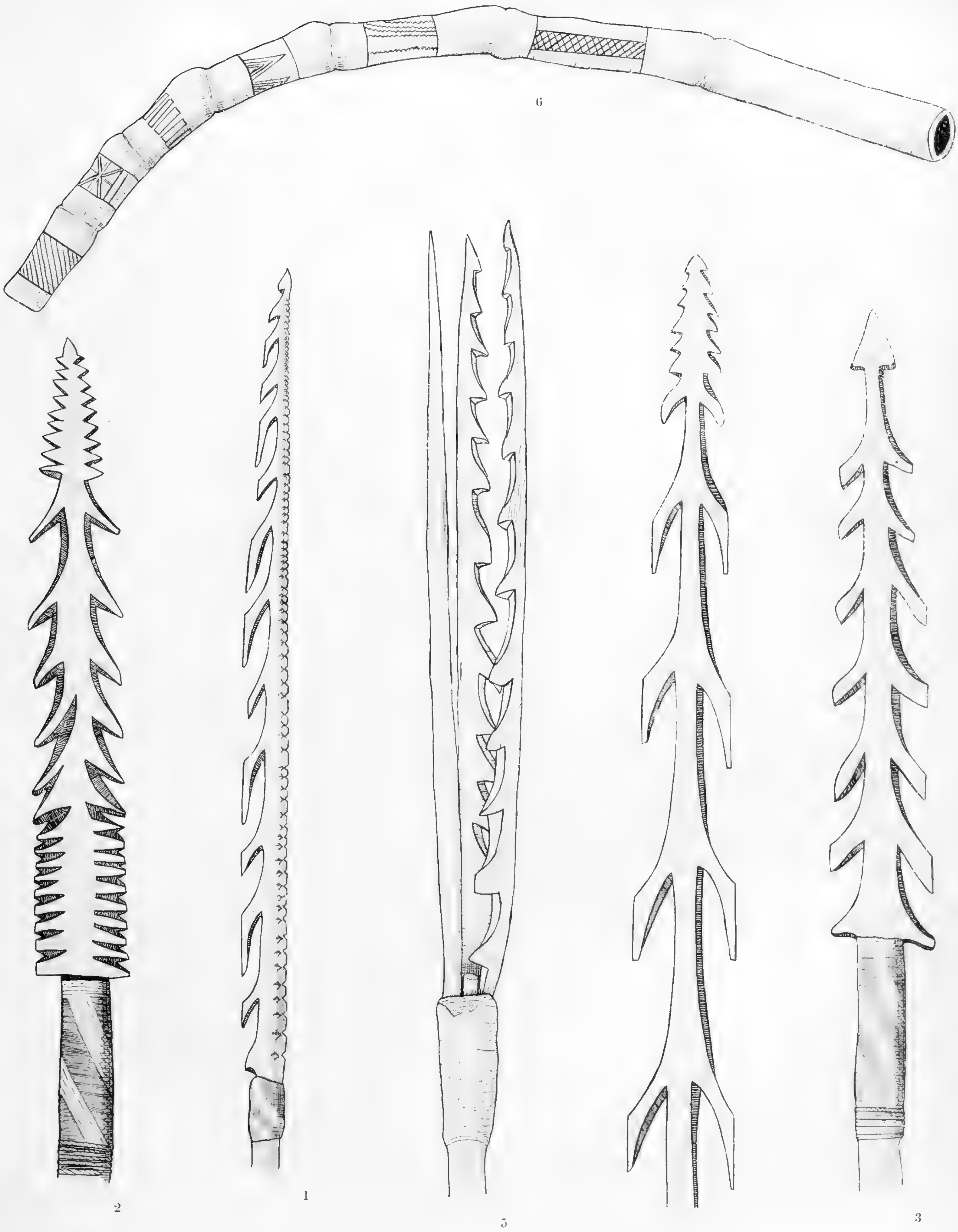
HAKEA BAKERIANA,



C. Hedley, del.

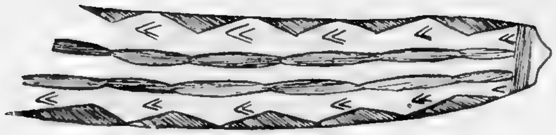
WEAPONS AND IMPLEMENTS OF THE ALLIGATOR TRIBE.

The Photoline Printing Co., Sydney.

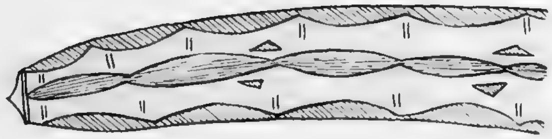


The Photoline Printing Co., Sydney.

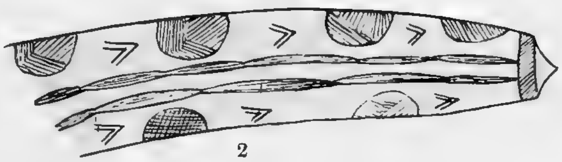
4



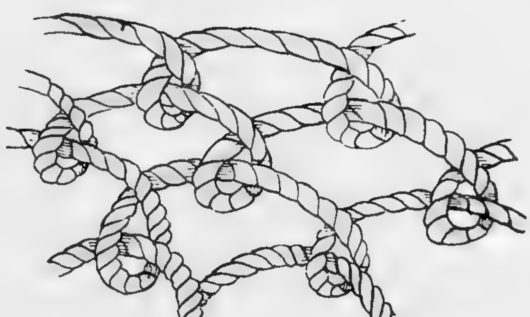
3



1

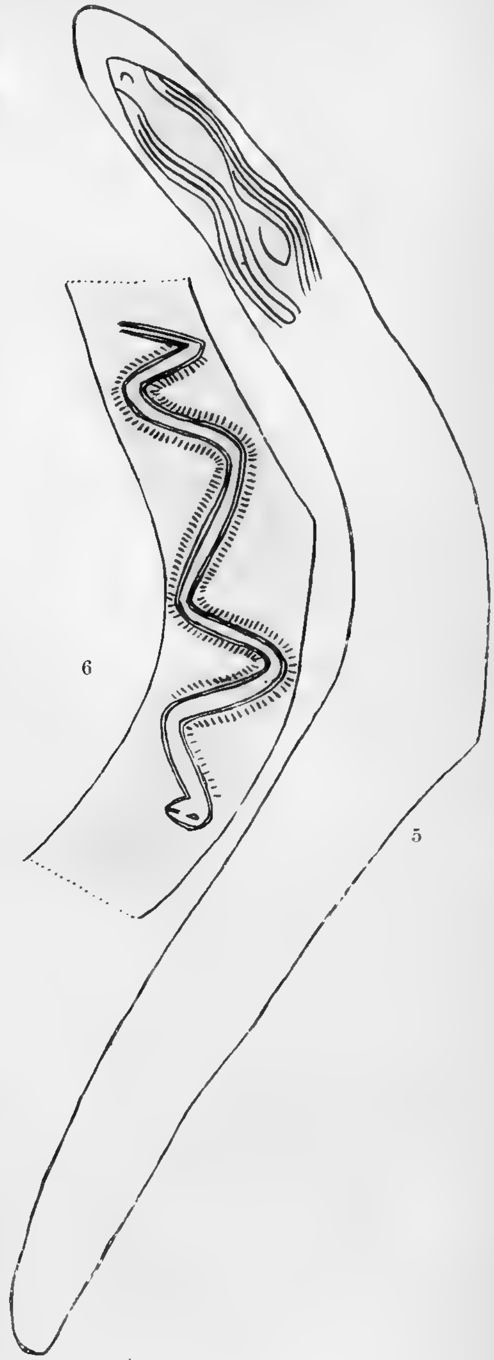


2



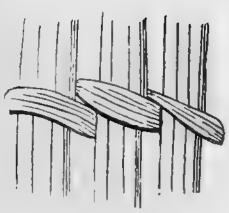
10

11

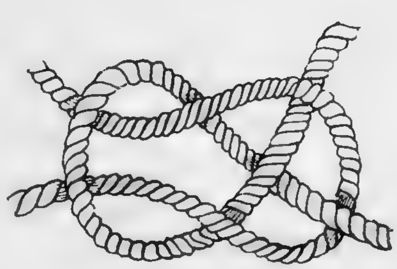


6

5



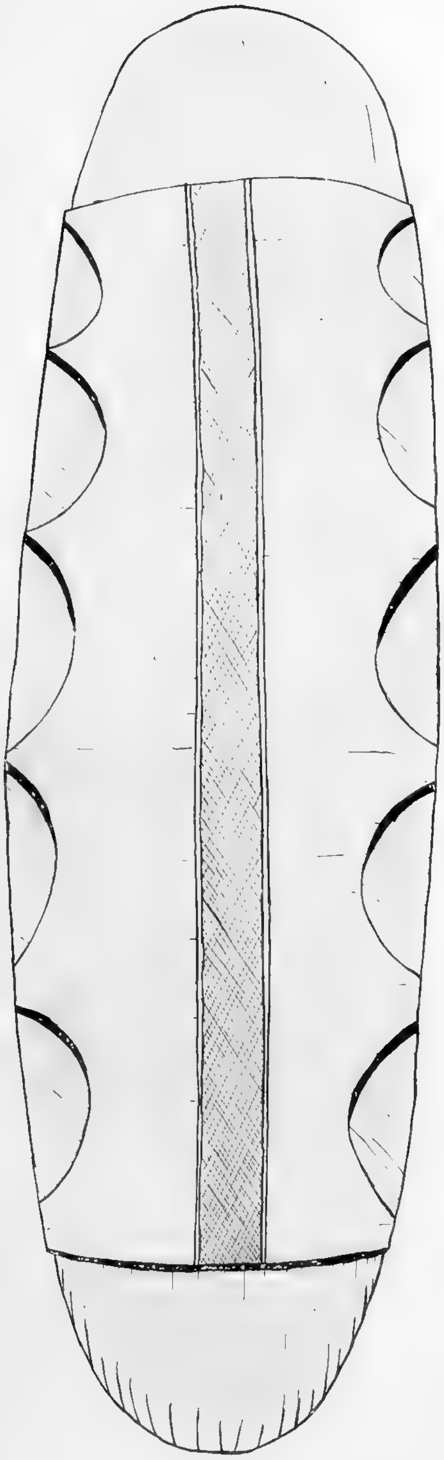
8



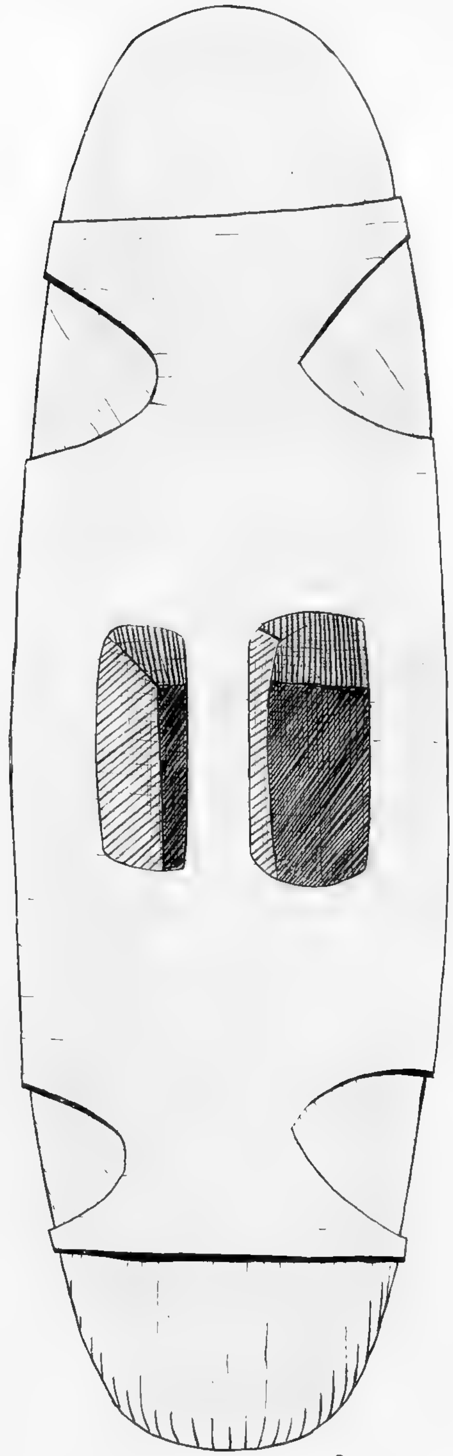
9

7

The Photoline Printing Co., Sydney.

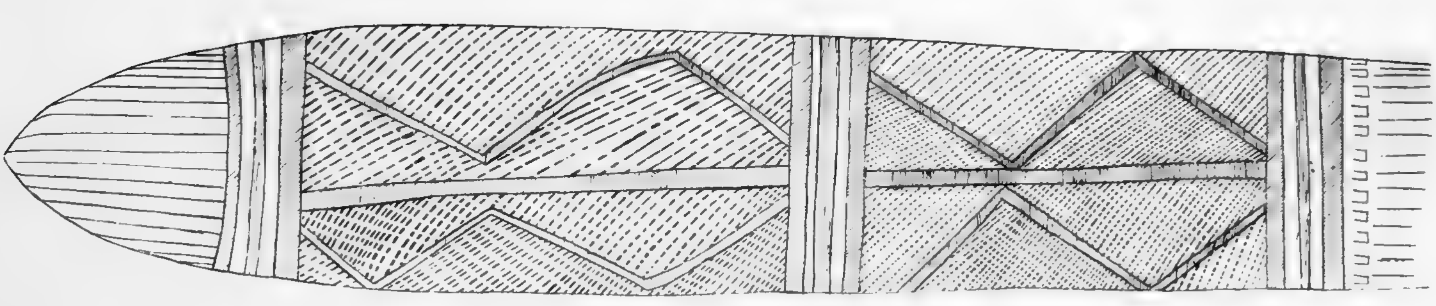


2



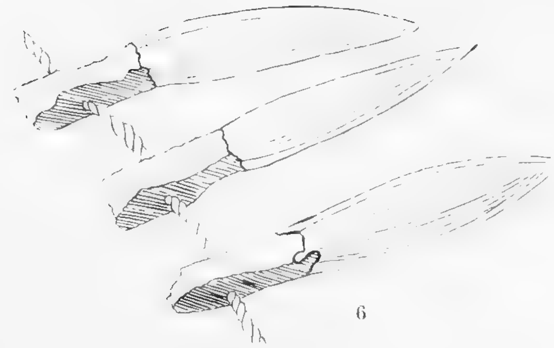
3

4

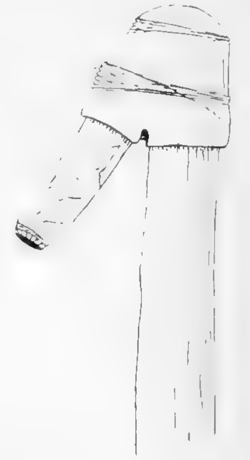


1

The Photoline Printing Co., Sydney

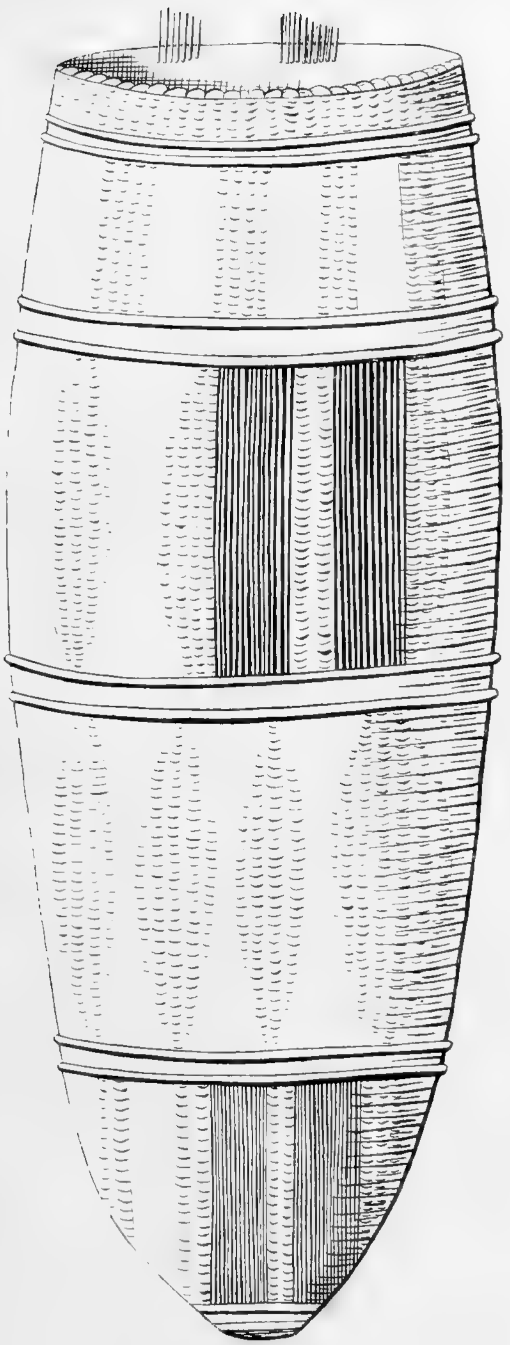


6

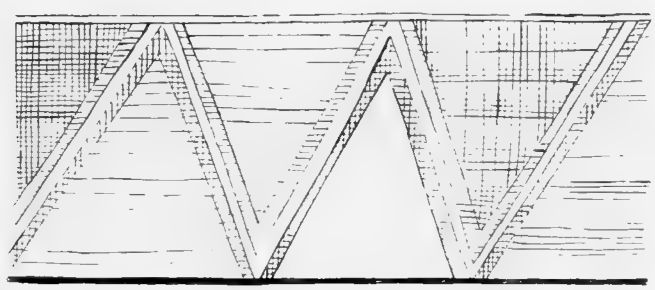


1

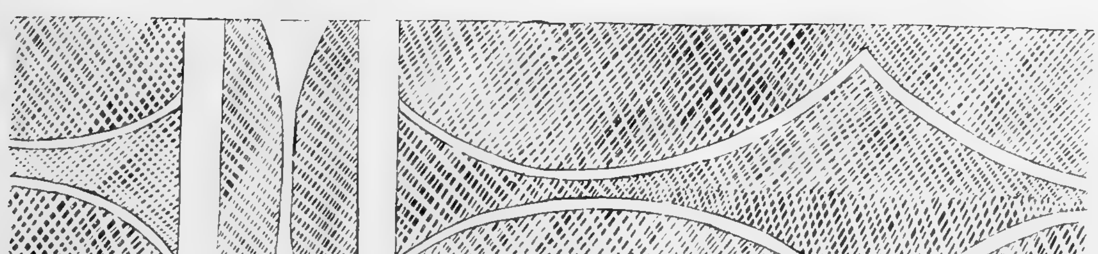
5



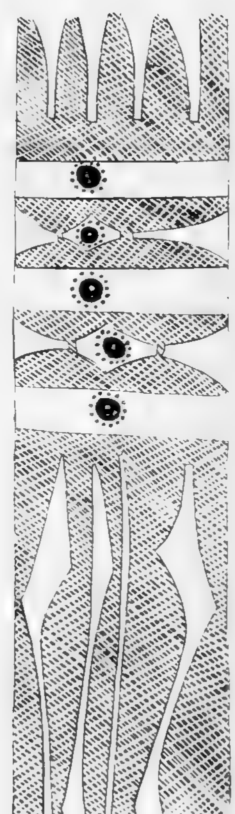
7



4



2



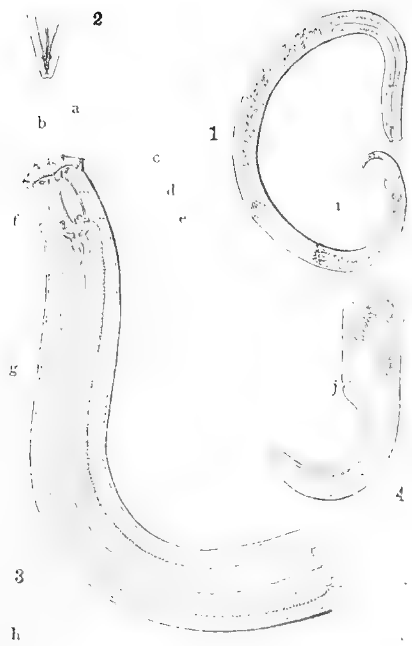
3

The Photoline Printing Co., Sydney.

1

2

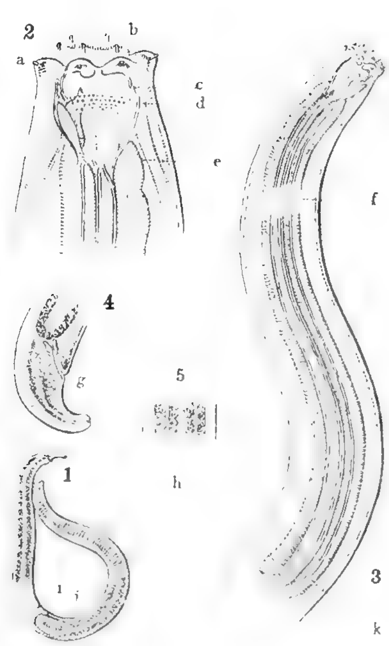
The Photoline Printing Co., Sydney



Mononchus digiturus, n. sp.

Mononchus gymnolaimus, n. sp.

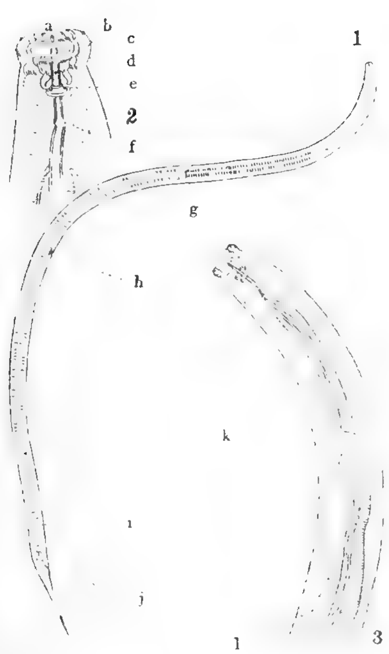
Rhabditis filiformis (?), B'ts'li.



Mononchus minor, n. sp.

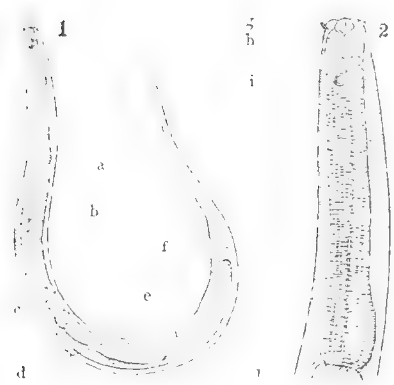
Nematodes; Banana-plants, Fiji.

Aulolaimus exilis, n. sp.

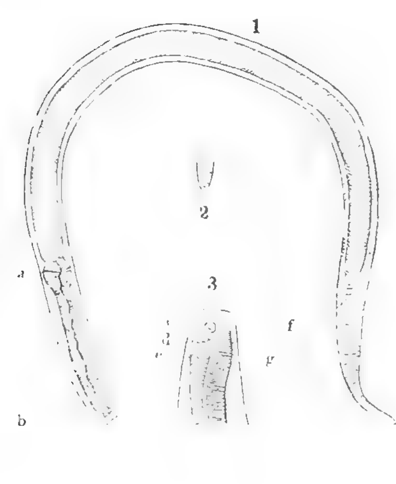


Dorylaimus labyrinthostomus, n. sp.

Chromadora minima, n. sp.

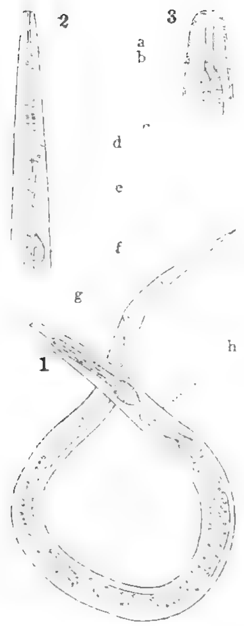


Monhystera rustica, B'ts'li.

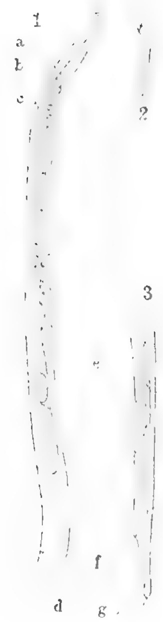


Chromadora Musae, n. sp.

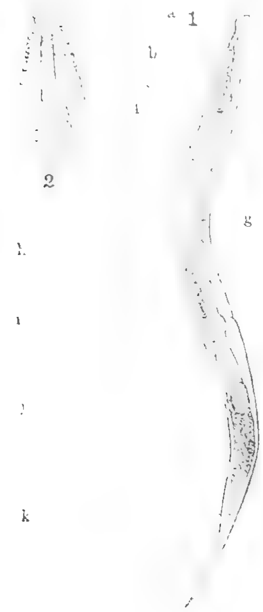
Nematodes; Banana-plants, Fiji.



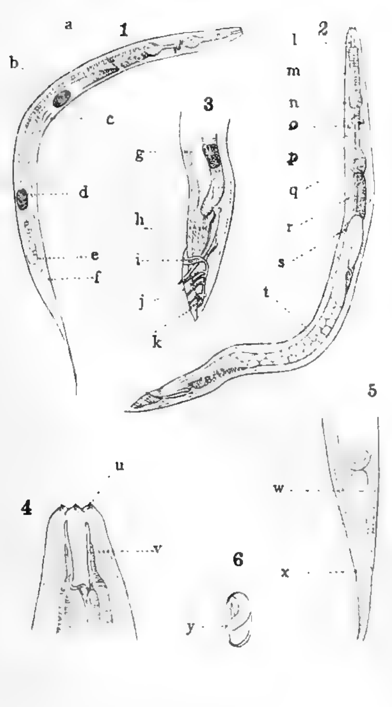
Young Rhabditis, sp. (?)



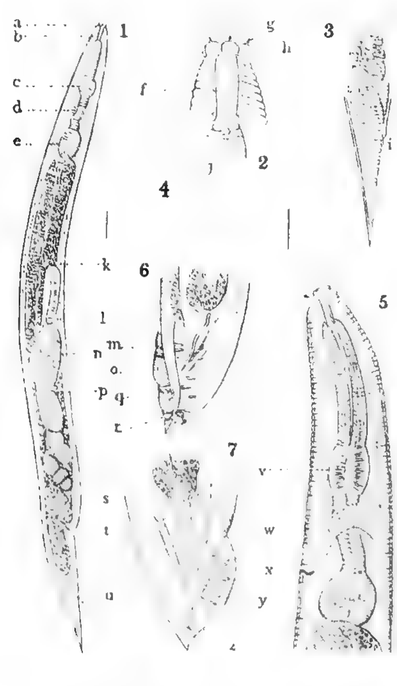
Aphelenchus minor, n. sp.



Rhabditis coronata, n. sp.

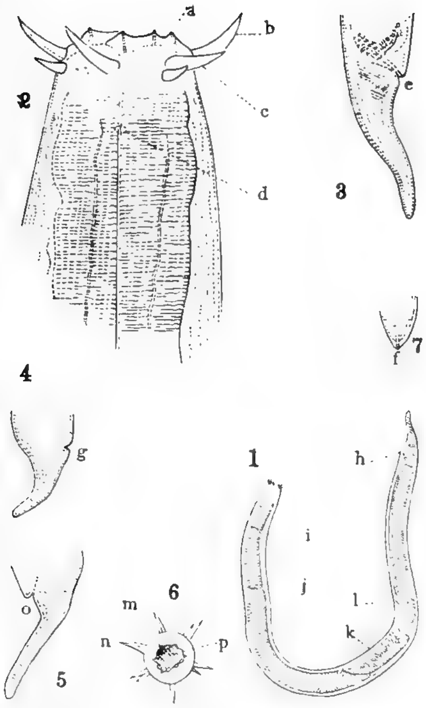


Rhabditis pellioides, B'ts'li.

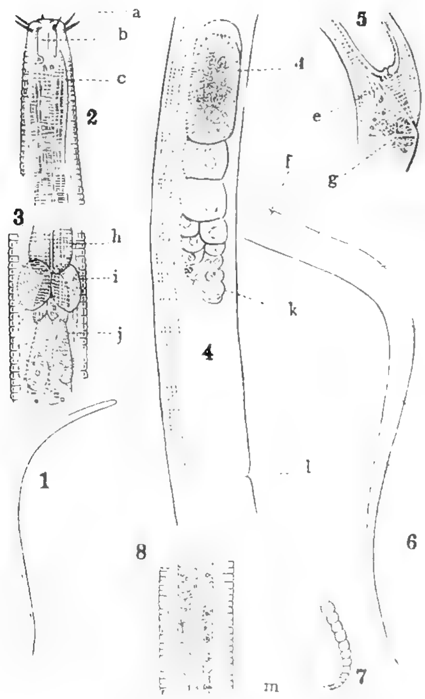


Rhabditis monhystera, B'ts'li.

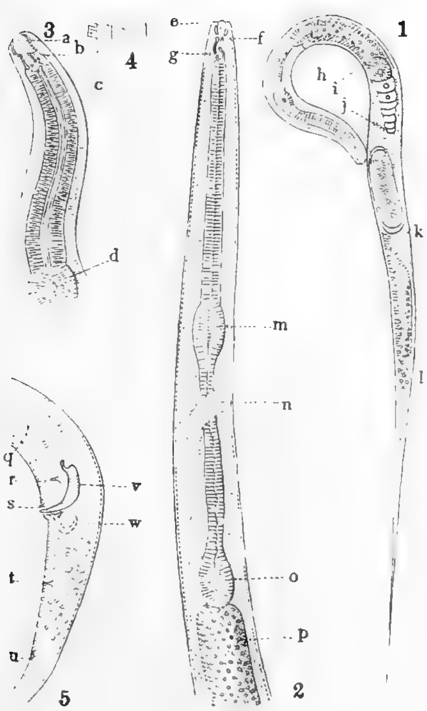
Nematodes; Banana-plants, Fiji.



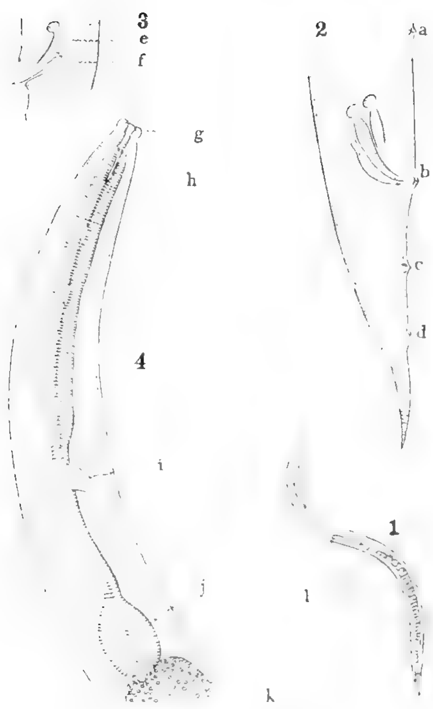
Tripyla minor, n. sp.



Prismatolaimus intermedius (?), B'ts'li.

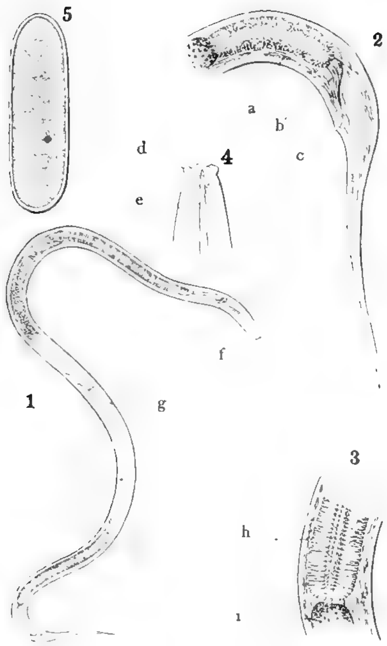


Figs. 2 and 5 Diplogaster parvus, n. sp.
Figs 1, 3 and 4 Diplogaster minor, n. sp.

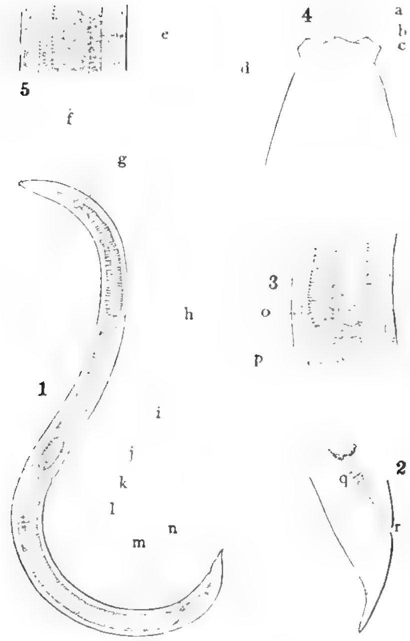


Cephalobus infestans, n. sp.

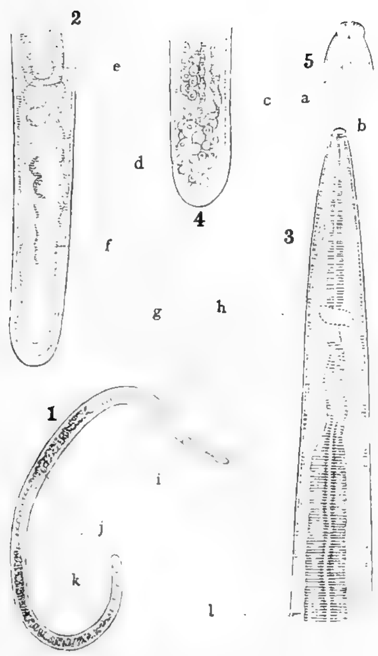
Nematodes; Banana-plants, Fiji.



Dorylaimus exilis, n. sp.



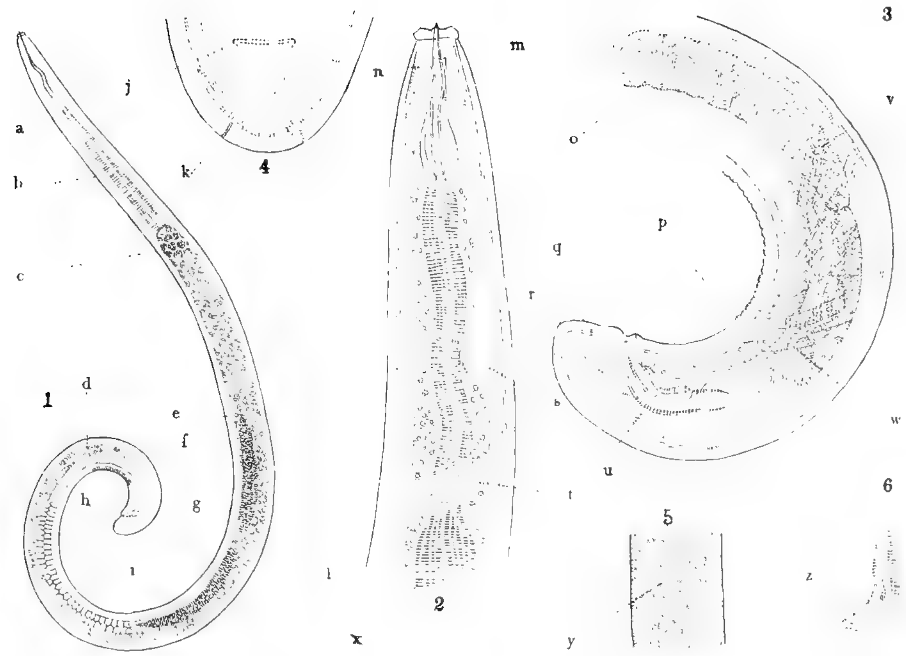
Dorylaimus granuliferus, n. sp.



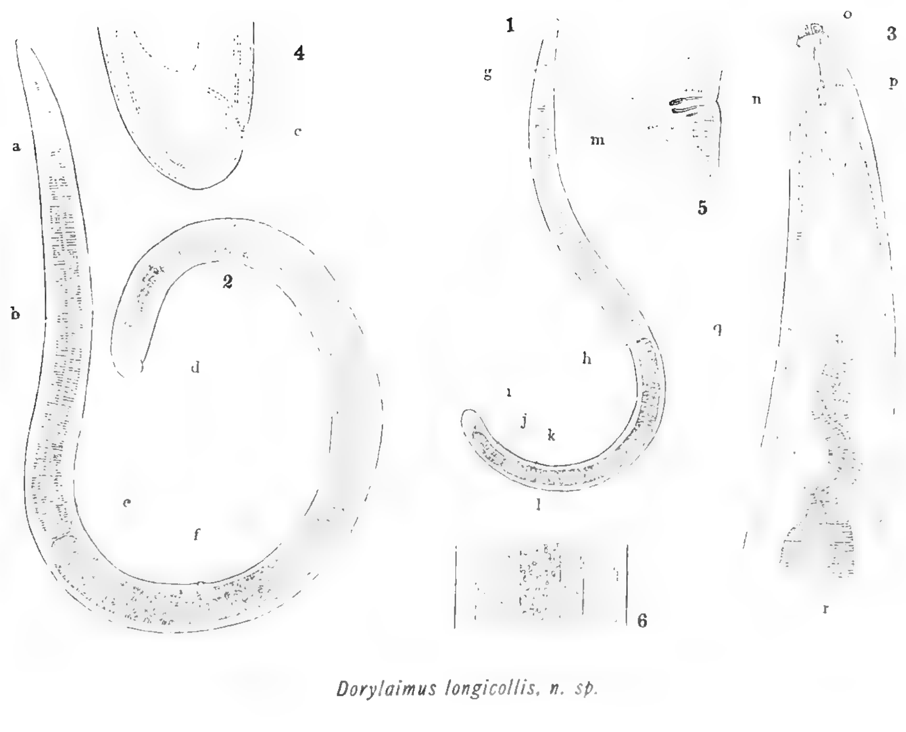
Dorylaimus obtusus, n. sp.

Dorylaimus perfectus (?), n. sp.

Nematodes; Banana-plants, Fiji.

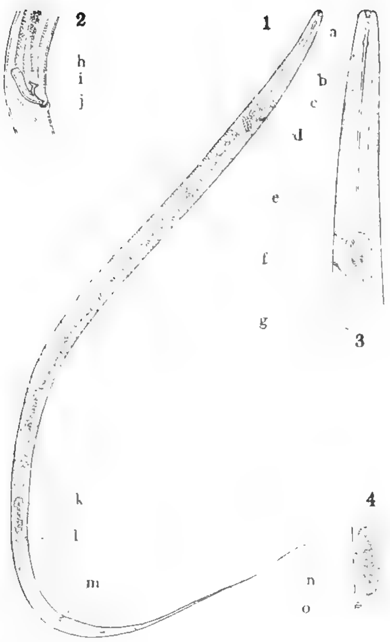


Dorylaimus perfectus, n. sp.

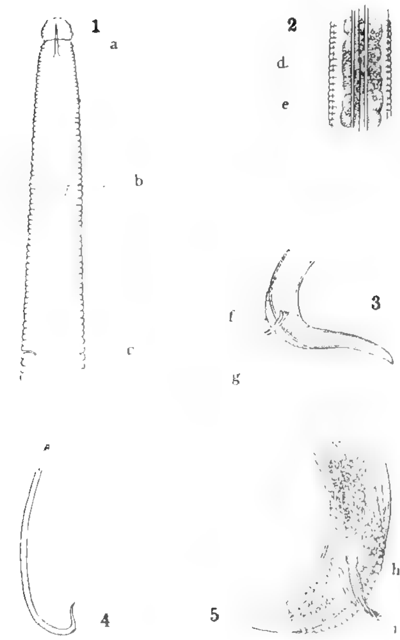


Dorylaimus longicollis, n. sp.

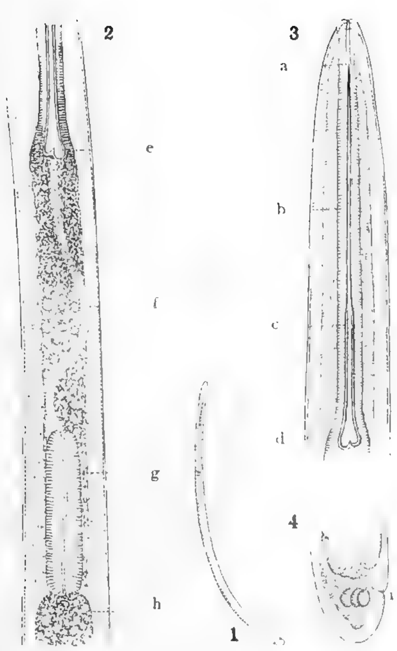
Nematodes; Banana-plants, Fiji.



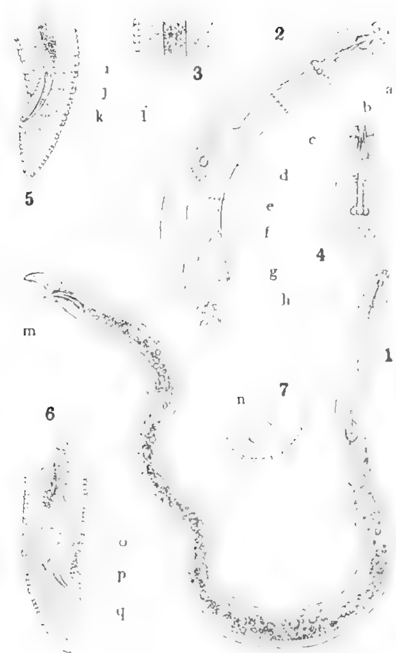
Aphelenchus longicaudatus, n. sp.



Tylenchus similis, n. sp.



Tylencholaimus ensiculiferus, n. sp.



Tylenchus multicinctus, n. sp.

Nematodes; Banana-plants, Fiji.

Linnean Society of New South Wales.

THE

MACLEAY MEMORIAL VOLUME

EDITED BY

J. J. FLETCHER, M.A., B.Sc.

PUBLISHED BY THE SOCIETY

AND SOLD BY

ANGUS & ROBERTSON, AND TURNER & HENDERSON, SYDNEY,

DULAU & CO., 37 SOHO SQUARE, LONDON, AND FRIEDLÆNDER & SOHN, BERLIN.

September, 1893.

Price Three Guineas.